SCIENCE LIBRARY
GENERAL LIBRARY
NOV 8 1918
UNIV. OF MICH.

VOLUME 8 NUMBER 10

OCTOBER, 1918

Phytopathology

Official Organ of the

American Phytopathological Society

CONTENTS

Potato Leaf-Roll: Its Diagnosis and Cause ..... E. J. Wortley 507
Varieties of Beans Susceptible to Mosaic. . Donald Reddick and Vern B. Stewart 530
Briefer Articles:
Two Tomato Diseases ..... Ernest Shaw Reynolds 535
An Automatic Spore Trap ..... F. D. Fromme 542
A Sterigmatocystis Smut of Figs ..... Robert W. Hodgson 545
A Storage Fermentation of Dasheens ..... Orville Turner Wilson 547
Reviews 550
Phytopathological Notes 551
Literature on Plant Diseases 552

PUBLISHED MONTHLY FOR THE SOCIETY

OFFICE OF PUBLICATION
2419-21 Greenmount Ave., Baltimore, Md.

Entered as second-class matter May 16, 1913, at the post office at Baltimore, Maryland, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917. Authorized on July 2, 1918.

Price { $5.00 per year, Domestic
$5.50 per year, Foreign

2169/13—Wolfhuegel's Counting Apparatus, consisting of Counting Plate No. 2169/17 with polished wooden base containing drawer for accessories.....$6.25

2169/26—Novy's Apparatus for Tube Cultures of Anaerobes, by gas or pyrogallate method. In two sizes: 150x80 mm. and 200x100 mm. with and without stopcocks.

SPECIALTIES:

Kavalier Bohemian Normal Glassware Best Grade of American Glassware, "Non-Sol," "Perfection" and "Pyrex;" Max Dreverhoff, Schleicher & Schuell, Swedish and English Filtering Papers; Royal Berlin and Haldenwanger Berlin Porcelain Ware; Best American Porcelain Ware; Troemner and Becker Balances and Weights; Platinum Wire, Foil and Ware; Fused Silica Laboratory Utensils "Vitreosil;" Hanovia Pure Transparent Quartz Glass; Alundum Ware; Hoskins' Electric Furnaces; Le Chatelier's Pyrometers; Bausch and Lomb Microscopes and Acessories; Hydrometers and Thermometers of every description; Chemically Pure Acids and Ammonia; Merck's, Baker and Adamson's and J. T. Baker Chemical Co.'s Chemicals and Reagents; Caustic Potash and Soda, purified in sticks and pure by alchohol; Acetate of Lead, Cyanide Mixture, Soda Ash and Commercial Caustic Soda.

HENRY HEIL CHEMICAL CO.

210-214 South 4th Street **St. Louis, Mo.**

THE JOURNAL OF CANCER RESEARCH

The official organ of the
American Association for Cancer Research

WILLIAM H. WOGLOM, *Editor*

The Journal is of interest from the practical and theoretical standpoints.
Five dollars a volume—United States and Canada.
Five dollars and fifty cents elsewhere.

Order from WILLIAMS & WILKINS CO.
Baltimore, U. S. A.

THE JOURNAL OF IMMUNOLOGY

Official Organ of the Society for Serology and Hematology and the American Association of Immunologists

ARTHUR F. COCA, *Editor*

The Journal is of interest from the practical and theoretical standpoints.
Five dollars a volume—United States and Canada.
Five dollars and fifty cents elsewhere.

Order from WILLIAMS & WILKINS CO.
Baltimore, U. S. A.

Books

AMERICAN Illustrated Medical Dictionary. By W. A. Newman Dorland, M.D. Ninth Edition. Octavo of 1179 pages, 331 illustrations. $5.00 net.

WHETZEL.—History of Phytopathology. By Herbert Hill Whetzel, Ph.D. 12mo of 130 pages, with portraits. $1.75 net.

FRED.—Soil Bacteriology. By E. B. Fred, Ph.D. 12mo of 170 pages, illustrated. $1.25 net.

JORDAN.—General Bacteriology. By E. O. Jordan, Ph.D. 6th Ed. Octavo of 691 pages, illustrated. $3.75 net.

W. B. SAUNDERS COMPANY
PHILADELPHIA AND LONDON

AMERICAN PHYTOPATHOLOGICAL SOCIETY

OFFICERS

1918

President, E. M. FREEMAN,
University Farm, St. Paul, Minn.

Vice-President, C. W. EDGERTON,
Experiment Station, Baton Rouge, La.

Secretary-Treasurer, C. L. SHEAR,
Pathologist, Bureau of Plant Industry, Washington, D. C.

ADDITIONAL MEMBERS OF THE COUNCIL

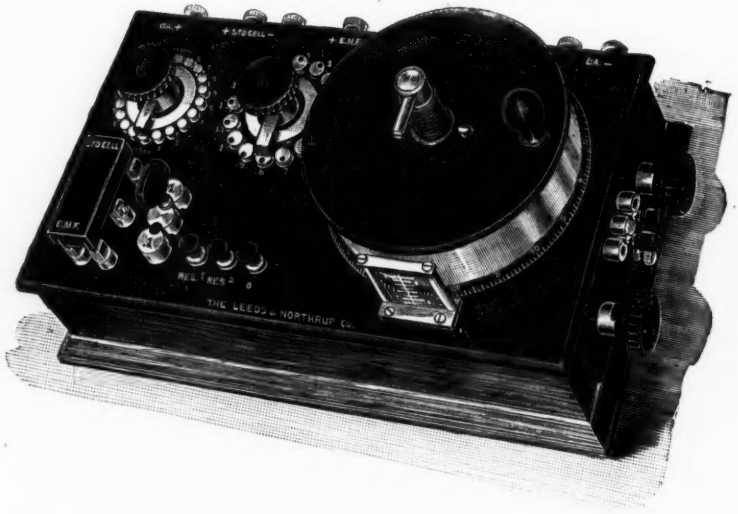
L. R. JONES,
Professor of Plant Pathology, University of Wisconsin, Madison, Wis.

H. S. JACKSON,
Chief in Botany, Purdue University Agricultural Experiment Station, Lafayette, Ind.

MEL T. COOK (*ex officio*),
Plant Pathologist, Rutgers College and New Jersey Agricultural Experiment Station, New Brunswick, N. J.

W. A. ORTON (*ex officio*),
Bureau of Plant Industry, Washington, D. C.

A POTENTIOMETER FOR THE DETERMINATION OF HYDROGEN ION CONCENTRATION IN SOLUTIONS



THE POTENTIOMETER illustrated above is now being used by a number of investigators for measuring the E. M. F. between the Hydrogen and Calomel electrodes in Hydrogen Ion Concentration determinations. It is rapidly replacing the electrometer for such work for the following reasons: first, it is much more sensitive than the electrometer; second, its use does not entail the annoying delays met with in the use of the electrometer when overcharged and thus polarized.

The Leeds and Northrup Potentiometer has two ranges. Normally measurements may be made up to 1.6 volts by steps of .00001 volt. A range changing plug enables measurements to be made up to .16 volt by steps of .000001 volt.

The precision of adjustment is such that on the high range measurements from .1 volt up may be made to a precision of better than 1/50%. On the low range measurements from .01 volt up may be made to the same degree of precision.

The instrument and its accessories require little or no attention. Its manipulation is simple.

A full description of this potentiometer will be sent upon request, as well as a list of some of those who are now using it for Hydrogen Ion Concentration determinations.

THE LEEDS & NORTHRUP CO.

ELECTRICAL MEASURING INSTRUMENTS

4930 STENTON AVENUE **PHILADELPHIA**

PHYTOPATHOLOGY

THE OFFICIAL ORGAN OF

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

EDITORS

W. A. ORTON
U. S. Department of Agriculture
Washington, D. C.

E. C. STAKMAN
University Farm
Saint Paul, Minn.

G. P. CLINTON
Agricultural Experiment Station
New Haven, Conn.

ASSOCIATE EDITORS

C. W. EDGERTON, Baton Rouge, La.	One year
H. T. GÜSSOW, Central Experimental Farm, Ottawa, Canada.	
N. J. GIDDINGS, Morgantown, W. Va.	
V. B. STEWART, Cornell University, Ithaca, N. Y.	
H. P. BARSS, Oregon Agricultural College, Corvallis, Ore.	Two years
H. A. EDSON, U. S. Department of Agriculture, Washington, D. C.	
G. M. REED, University of Missouri, Columbia, Mo.	
J. B. RORER, Board of Agriculture, Port of Spain, Trinidad.	
J. T. BARRETT, Riverside, Calif.	Three years
F. D. FROMME, Blacksburg, Va.	
W. J. MORSE, Orono, Maine.	
I. E. MELHUS, Ames, Iowa.	

BUSINESS MANAGER

C. L. SHEAR, U. S. Department of Agriculture, Washington, D. C.

EDITORIAL NOTICES

Manuscript for Publication or correspondence relative thereto may be addressed to W. A. Orton or to any other member of the Editorial Board. Contributors are requested, so far as convenient, to carry on preliminary correspondence and submit copy of manuscript to the nearest Associate Editor. For instance, correspondence from Canada may be addressed to H. T. Güssow, from the Pacific coast to H. P. Barss or J. T. Barrett, from the Tropics to J. B. Rorer and so forth.

Manuscripts should be typewritten and carefully revised before submission. While no attempt will be made at exact uniformity in capitalization, punctuation, spelling, citations, footnotes, etc., each contributor is requested to give careful attention to clearness and preciseness in these matters and to conform as far as practicable to the best usage in this journal.

Phytopathological Notes. Manuscript for this department should be sent to H. A. Edson, U. S. Dept. of Agriculture, Washington, D. C.

Reviews. Publications for review should be sent to H. A. Edson, U. S. Dept. of Agriculture, Washington, D. C.

Illustrations. A limited number of illustrations will be accepted. Only the very best photographs can be reproduced satisfactorily by the processes available to the journal. Authors desiring special types of reproduction may be asked to bear part of the expense. Line drawings reproduce very satisfactorily on regular text paper and usually should be submitted for use as text figures rather than as plates. Attention is called to the reproduction of photographs as text figures on a coated paper. For such purposes photographs should be submitted untrimmed and unmounted. Semi-matt printing paper is often preferable to the glossy paper.

BUSINESS NOTICES

Subscription price. $5.00 per year for all points within the United States; foreign subscriptions, $5.50; current single numbers 50 cents. The journal will be issued monthly beginning with Vol. VIII, January, 1918.

Requests to supply lost copies of the journal must be made within 40 days from date of issue. Date of issue January 1 and monthly thereafter.

Separates. No gratis copies are supplied. A printed schedule of prices is submitted with the proof and authors may secure separates by placing an order with the publishers when proof is returned.

Back Volumes may be obtained unbound at $5.00 per volume, postage paid.

Separate copies will not be sold except in cases where the volumes are already broken. The price of such copies is 85 cents each.

Make all remittances payable to Phytopathology. Address all business correspondence to The Williams & Wilkins Co., 2419-21 Greenmount Ave., Baltimore, or to C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

SUGARS

FOR USE IN BACTERIOLOGY

DEXTROSE, Bacto, "Difco," a carefully tested and uniform product, free from all other sugars and from starch, proteid, alcohol and heavy metals

Per ¼ lb. package	1.25
" ½ lb. "	2.45
" 1 lb. "	4.80

DEXTROSE, Mulford, pure, specially prepared for bacteriological work

Per 50 gram package	1.25
" 250 gram "	5.25
" 500 gram "	10.00

GALACTOSE

Per 1 oz. package	.91
" ¼ lb. "	2.93

INULIN, Mulford, specially prepared for bacteriological work

Per 10 gram package	2.75
" 100 gram "	25.00

LACTOSE, Bacto, "Difco," guaranteed free from Dextrose. A very fine, pure white powder free from odor and completely soluble in water

Per ¼ lb. package	.68
" ½ lb. "	1.30
" 1 lb. "	2.50

LACTOSE, Mulford, pure, free from Dextrose, specially prepared for bacteriological work

Per 50 gram package	.90
" 250 gram "	3.50
" 500 gram "	6.50

***MANNITE**

Per 1 oz. package	.39
" ¼ lb. "	1.34
" 1 lb. "	5.25

SACCHAROSE, c. p., Baker Analyzed

Per ¼ lb. package	.34
" 1 lb. "	1.39

SALICIN, for use in work on streptococci. Per 1 oz. package 2.60

*NOTE—Subject to some delay in delivery owing to small supply available

Prices subject to change without notice

ARTHUR H. THOMAS COMPANY

IMPORTERS—DEALERS—EXPORTERS

LABORATORY APPARATUS AND REAGENTS

WEST WASHINGTON SQUARE PHILADELPHIA, U. S. A.

PHYTOPATHOLOGY

VOLUME VIII NUMBER 10

OCTOBER, 1918

POTATO LEAF-ROLL: ITS DIAGNOSIS AND CAUSE

E. J. WORTLEY

I. LOSSES IN BERMUDA FROM LEAF-ROLL

I. Losses in Bermuda from leaf-roll 508
II. The diagnosis of leaf-roll 510
1. Symptoms of leaf-roll 513
2. Period in the plants growth when the disease may be determined 515
3. Confusion of other troubles with leaf-roll 516
III. The cause of leaf-roll 517
1. European theories as to the cause of leaf-roll 517
2. Climatic influences as an important factor in the production of leaf-roll 518
(a) The influence of drought on strains of Bliss Triumphs at the Agricultural Station in Bermuda in 1914 519
(b) The appearance of leaf-roll in Bliss Triumphs replanted for several seasons in Bermuda 520
(c) Leaf-roll in strains of potatoes obtained from Ottawa compared with the same strains from Fredericton, New Brunswick 524
(d) Leaf-roll in northern stock replanted for two seasons on Long Island 525
3. Soil infection not a factor of any importance in the production of leaf-roll in Bermuda 526

Two main crops of potatoes are grown annually in Bermuda and exported to the New York market. In the fall, the red Bliss Triumph is planted, mostly from seed imported from Long Island; in January and February, the Chili Garnet is grown from stock imported from Nova Scotia. In addition a small crop of Bliss Triumphs is grown in the Spring from "seed" obtained direct from Maine to produce "seed" for replanting in Bermuda in the early fall.

On taking charge of the Department of Agriculture of Bermuda in 1913, it soon came to my notice that the farmers were suffering heavy losses

through the importation of poor strains of "seed" potatoes that produced varying percentages of low-yielding plants, which investigation proved to be affected with leaf-roll (figs. 2 to 4).

The losses given below will show what serious proportions the matter was assuming. In every case quoted there was clear evidence that leaf-roll was the cause of the loss.

Instances of loss, from imported seed potatoes affected by leaf-roll, 1913 and 1914

	BARRELS PLANTED	BARRELS REAPED MARKETABLE	CONSERVATIVE ESTIMATE OF NORMAL CROP
Bliss Triumphs from Long Island:			*barrels*
1. R. J. Johnson	25	19	50
2. B. C. C. Outerbridge	6	10	36
3. E. R. Outerbridge	37	110	222
4. S. Ingham	1	1	6
5. M. C. Benevides	4	6	24
6. Joe Simons	4	5	24
7. J. DeSilva	3	2	18
8. A. Semoa	8	13	48
9. M. Carreira	100	300	600
10. A. Doe	30	30	180
Total		496	1308
Loss from leaf-roll			812
Garnets from Nova Scotia:			
1. F. Marshall	12	¼	96
2. F. Simons	20	30	160
3. M. D. DeSilva	7	Ploughed under	56
4. M. DeSousa	8	Ploughed under	64
5. A. Marshall	3	Ploughed under	24
6. J. C. White	20	30	106
7. W. C. Peniston	8	24	64
8. F. Marshall	7	14	56
9. P. Carreira	3	11	24
10. A. DeCouts	56	110	448
Total		219¼	1152
Loss from leaf-roll			932¾

Potato culture, owing to leaf-roll in the stock, had become a speculative venture of a hazardous character and success depended more upon the accident of the kind of seed obtained than it did upon the industry and skill of the cultivator. A farmer who won a prize for yield in 1914, reap-

ing eighteen barrels from one planted, the following season obtained only nineteen barrels from twenty-five planted. In the former case he had the good fortune to get healthy stock. The next year leaf-roll stock fell to his lot.

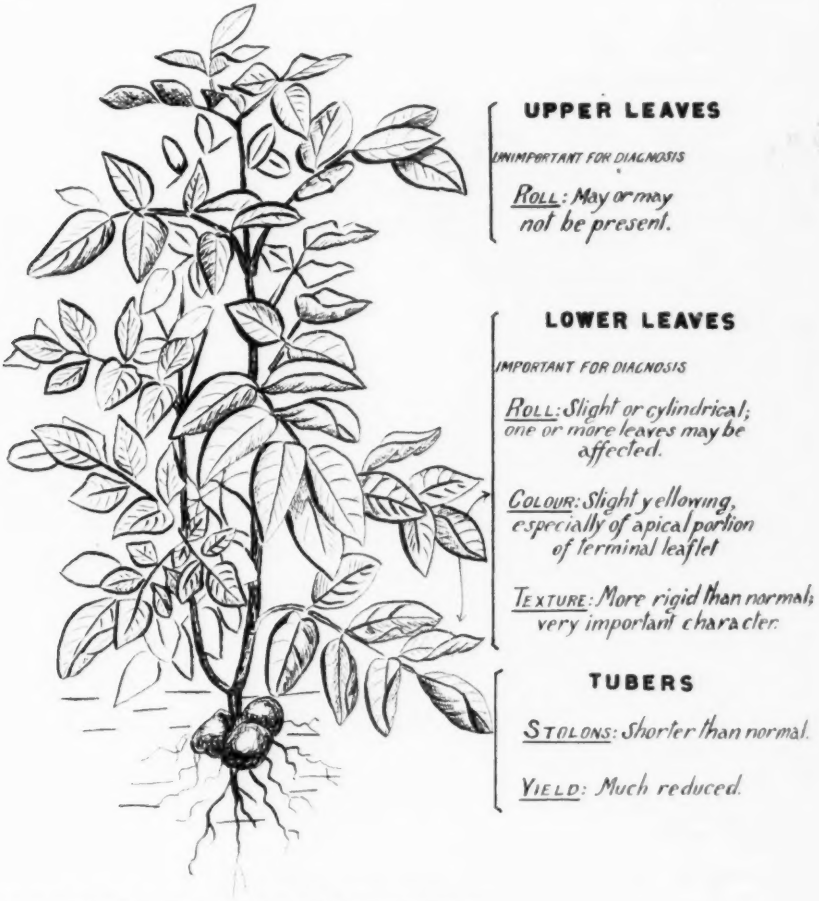

UPPER LEAVES
UNIMPORTANT FOR DIAGNOSIS
ROLL: May or may not be present.
LOWER LEAVES
IMPORTANT FOR DIAGNOSIS
ROLL: Slight or cylindrical; one or more leaves may be affected.
COLOUR: Slight yellowing, especially of apical portion of terminal leaflet
TEXTURE: More rigid than normal; very important character.
TUBERS
STOLONS: Shorter than normal.
YIELD: Much reduced.
LEAF-ROLL CHARACTERS
DIAGRAMMATIC REPRESENTATION

FIG. 1. LEAF-ROLL CHARACTERS

The farmers and merchants in the north were genuinely unaware of the presence of leaf-roll and voluntary assistance could not be obtained from them. Strict Government regulations were, therefore, passed controlling the importation of seed potatoes into Bermuda. Field inspections were

carried out and the coöperation of federal and resident officers in Canada and the United States was sought. As a result it is now possible to report that leaf-roll has at last been eliminated as a factor of commercial importance in Nova Scotia stock and has been much reduced in that from Long Island.

FIG. 2. HEALTHY CHILI GARNETS IN NOVA SCOTIA

FIG. 3. LEAF-ROLL IN CHILI GARNETS IN NOVA SCOTIA

II. THE DIAGNOSIS OF LEAF-ROLL

In view of the general confusion that has crept into the literature on leaf-roll, it is extremely desirable, if not imperative, that any one who now writes on the subject should place very clearly before the reader evidence that no mistake has been made in diagnosis and that reference is made to genuine leaf-roll.

It would appear to be particularly important that I should do this, as the type of plant that my experience leads me to believe is the form in which leaf-roll is commonly manifested in Canada, the United States, and Bermuda, differs in some respects from the European type described and illustrated by Dr. W. A. Orton in his bulletin on "Potato Wilt, Leaf-Roll and Related Diseases" (1).

Doctor Orton deserves the gratitude of potato workers on two important counts. First, for having put so clearly before English readers the result of his study of the voluminous, and, to many, inaccessible, European literature on leaf-roll; and, secondly, for having first differentiated between

non-parasitic leaf-roll and other potato troubles of a parasitic character in which a rolling of the leaves is evident. The action of Appel in accepting Doctor Orton's claim that the term "leaf-roll" should be confined to the non-parasitic trouble, while throwing doubt on the value of a great deal of the previous European work, should do much to prevent a continuation of the confusion in the literature of that continent.

To return to the question of diagnosis, there now appears to exist a somewhat uncertain conception of even the more striking diagnostic

FIG. 4 HEALTHY STOCK (ON LEFT) AND LEAF-ROLL STOCK (ON RIGHT) IN BERMUDA

The result of planting tubers from strains similar to those shown in figures 2 and 3.

characters of this serious trouble, and the determination and general acceptance of the symptoms by which leaf-roll may be accurately and readily diagnosed, is one of the most important points that still remain to be cleared up. It is hoped that acceptance of the roll and rigidity of the lower leaves as the principal characteristic feature will prevent much of the present confusion.

Leaf-roll has been observed on many varieties of potatoes and scattered over wide areas More than sixty varieties of potatoes affected by this

disease have been examined in America by the writer (in the East from Florida to Maine, in the Middle West and West in Michigan, Minnesota and Colorado); in Canada (in the provinces of Ontario, Quebec, New Brunswick, Nova Scotia and Prince Edward Island); and in Bermuda.

It is fair to record that in the states and provinces named leaf-roll has not been observed on a scale that would warrant general alarm or justify any reflection on those districts now noted as seed centres. The primary interest that attaches to the wide distribution reported above is the fact that under the most varied conditions the principal diagnostic characters

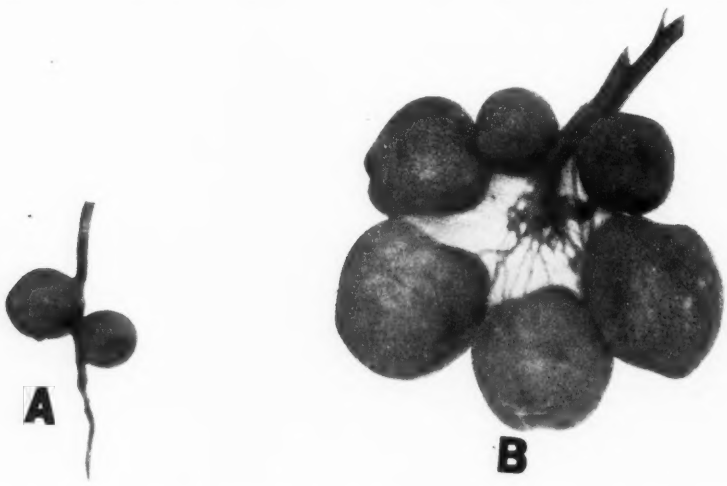


FIG. 5. LOSS IN YIELD DUE TO LEAF-ROLL. *A*, LEAF-ROLL; *B*, HEALTHY

are constant and can be confidently detected in spite of minor differences due to variety or climate. The symptoms may be summarized as follows:

A. CONSTANT CHARACTERS

1. Most important diagnostic characters

Lower Leaves. The diagnosis of leaf-roll is most readily and accurately made by examination of the *lower leaves*, one or more of which will show the following characters:—

(a) *Roll.* One or more leaflets may be affected; the roll may be only a slight upturning of the margins (fig. 9) or may be cylindrical (fig. 7 B).

(b) *Colour.* Yellowish, especially the apical portion of the terminal leaflets (fig. 9).

(c) *Texture.* The rigid character of the affected leaf or leaflet is *a very important diagnostic character* (fig. 9). The 'feel' is hard and crisp. The terms brittle, turgescent, rigid, leathery, have been used to describe this condition. Leaves showing symptoms of leaf-roll do not wilt and become limp during drought as normal leaves do.

2. Other important constant diagnostic characters

Size of plant. A plant affected by leaf-roll is smaller than neighbouring healthy plants (figs. 7B, 8B).

Colour of foliage. The plant as a whole has a slight, but plainly discernible, yellow cast. This character is more pronounced during dry weather than after rains.

Yield. A marked reduction in yield, commonly amounting to 50 per cent or more, is an invariable character of leaf-roll (fig. 5).

Stolons. The stolons are shorter than normal and the tubers are sometimes borne directly on the stem (fig. 1).

Transmission of disease. The disease is transmitted by the planting of tubers from affected plants.

B. COMMON BUT NOT CONSTANT CHARACTERS

Roll of upper leaves. The upper leaves may (fig. 6) or may not (fig. 10 A) be conspicuously rolled. If a soft wilt-like roll of all the leaves is noticed it should be regarded as good grounds, pending an examination of the lower leaves, for suspecting that the plant is *not* affected with leaf-roll.

Purplish, reddish, or bluish discolouration of affected leaves. This character varies according to the variety, the season, and apparently also the climate; it is most pronounced, and sometimes only noticeable, on the lower leaves.

Habit of growth. An abnormally erect and V-shaped growth is frequently observable (fig. 15). A "truncate" appearance is, however, not uncommon (fig. 8). The character of the variety has some influence on the habit of growth.

Seed piece. The seed piece is commonly found intact, but this character is far from constant, and during the summer season in Bermuda there is often little decay in seed pieces of healthy plants.

1. SYMPTOMS OF LEAF-ROLL

The symptoms outlined above are in a great measure those reported by European workers, but there is one important point in which a difference may be noted. The rolling is said to be sometimes restricted to the upper leaves and the value of the rolling and rigidity *of the lower leaves* as a means of diagnosis is ignored. As a matter of fact, in a number of varieties the rolling of the upper leaves *is not particularly conspicuous;* and, often, it is only by examining the lower leaves that the trouble is recognized. The rolling of the lower leaves, indeed, appears to have made very little impression on German workers, as may be judged from the fact that one of the plates used by Appel (2) to illustrate leaf-roll shows only the upper portion of a potato stem, the lower leaves having been cut off.

With regard to the claim made in this article, that the lower leaves are by far the most important feature to be considered in diagnosing leaf-roll, it is interesting to note that the "Secondary" type of leaf-roll described by Quanjer (3) in his recent work on leaf-roll corresponds very closely indeed with the type of leaf-roll observed by the writer in Canada, the United States,

and Bermuda. Quanjer lays stress on the rolling and rigidity of the lower leaves in his secondary type, but he also describes a "primary" type of leaf-roll in which the upper leaves only are rolled. Up to the present, the writer has failed to discover in any of the many varieties of potatoes examined anything that would correspond to this type. In the case of the Bliss Triumph and Chili Garnet, tubers from plants that showed any variation from the normal have repeatedly been planted, but without success, in an effort to discover an intermediate stage between a healthy

FIG. 6. *A*, LEAF-ROLL; SYMPTOMS IN LOWER LEAVES; *B*, LEAF-ROLL; ALL THE LEAVES ON THE PLANTS CONSPICUOUSLY ROLLED; *C*, HEALTHY

plant and one typically affected with definite symptoms in the lower leaves. Quanjer reports that in some cases his secondary type develops directly from the normal. In the many hundreds of cases observed in which the progeny of healthy plants have had leaf-roll, all the affected plants have shown the roll most conspicuously in the lower leaves and there has been no evidence of an intermediate type.

Orton (1) states that in the Colorado outbreak of 1911–14 aerial tubers were frequent and also illustrated plants showing adventitious tubers on the stolons as well as aerial tubers. The writer does not regard aerial

tuber formation as a characteristic of leaf-roll and considers that the cases reported must have been due to other complicating local conditions.

2. PERIOD IN THE PLANT GROWTH WHEN THE DISEASE MAY BE DETERMINED

Leaf-roll may be first detected from five to eight weeks after the "set" is planted and it is safe to assume that if there are no evidences of leaf-roll when the plants are nine weeks old the disease will not develop later. Field counts of the disease are best made before the plants cover in the

FIG. 7. CHILI GARNETS, BERMUDA. *A* AND *C*, HEALTHY, *B*, LEAF-ROLL

rows. When the plants are fully grown the disease can still be definitely determined but specimens cannot be picked out with the same rapidity owing to the overlapping of the foliage of neighboring plants.

It has been noticed in Bermuda that when the plants approach maturity and begin to "go back" the discoloration or yellowish cast of the affected plants is more pronounced than at any other period. It is, however, inadvisable to postpone the examination for leaf-roll until late in the season as blight may attack the plant and obscure the symptoms or the lower leaves may be found to have rotted.

3. CONFUSION OF OTHER TROUBLES WITH LEAF ROLL

Examination of a few cases of genuine leaf roll and acceptance of the diagnostic value of the symptoms manifested on the lower leaves will largely prevent the danger of errors in diagnosis. Doubtful cases will be seen from time to time, but as a rule it will be safe to assume that leaf-roll is not present if doubt is felt, after thorough examination of the suspected plant has been made by an observer familiar with the disease.

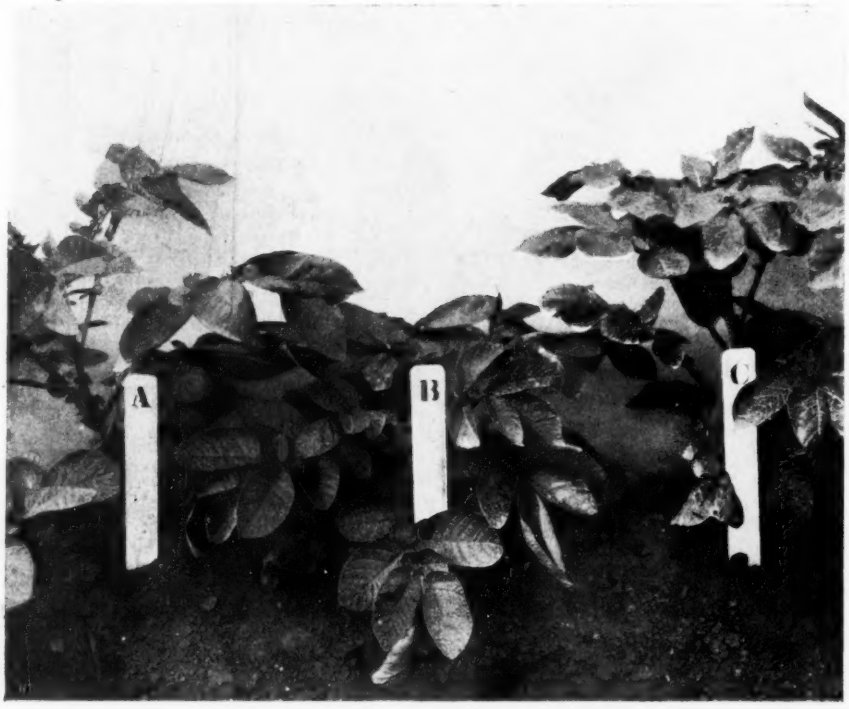


FIG. 8. BLISS TRIUMPHS, BERMUDA. *A* AND *C*, HEALTHY, *B*, LEAF-ROLL

Fusarium, Verticillium and bacterial wilt may be distinguished by the limp character of the wilted leaves, by the late period at which the plants are attacked, and by the browing of the fibro-vascular strands.

Varieties of potatoes with rolled leaves, drought affected plants, and specimens attacked by Rhizoctonia on the roots and stolons only, are probably more likely to be confused with leaf-roll.

Varietal characters. Some varieties of potatoes in health show a roll of the upper leaves that may be confused with leaf-roll, if undue importance

is attached to the character of the upper leaves. This is particularly true of seedling and other varieties the leaves of which naturally show a reddish or purplish tinge.

Drought affected plants. A rolling of the leaves due to drought is sometimes mistaken for leaf-roll and the following differences should be noted: Leaf-roll plants do not show the effect of drought to the same extent as normal plants. Affected by leaf-roll, the lower leaves are turgid; affected by drought, they are limp. The distribution of leaf-roll is generally sporadic in commercial fields; the influence of drought is general over an affected area. The comparative lack of response to drought conditions is a striking feature of leaf-roll.

Rhizoctonia. There is no danger of confusing pronounced Rhizoctonia with leaf-roll, but there is a condition that has often been noticed when the plant appears normal but for a distinct rolling of the leaves, especially the upper ones. Superficial examination of the plant offers no explanation, but if it is carefully dug up the roots and stolons will show darkened patches bearing on the surface the characteristic mycelium of Rhizoctonia (fig. 11).

III. THE CAUSE OF LEAF-ROLL

1. EUROPEAN THEORIES AS TO THE CAUSE OF LEAF-ROLL

Before dealing with the conclusions drawn as to the important rôle played by climatic conditions in the production of leaf-roll, it would be well to first consider the European theories as to the cause of the disease. Workers in Europe have naturally been much concerned by the losses due to leaf-roll and have been eager to determine the cause. Many theories have been advanced, but none have been accepted as proven.

With regard to these, Orton (1) writes: "The hypotheses as to the cause of leaf-roll are numerous but exceedingly varied. They have indeed only one point in common—that all are as yet unproved." This author goes on to state that the cause of leaf-roll has been attributed to the use for seed of unripe, or immature tubers, or tubers from prematurely expired plants; to a lack, or an over-supply of mineral elements in the soil; to poor cultural methods; to lack of seed selection; and to varietal degeneration. It will be noted that almost every phase of potato culture except climatic influence has been suggested as the cause.

Quanjer (4) in a recent work says, "There are almost as many theories as to the cause of leaf-roll as there are authors." Quanjer himself claims that it is due to a virus and that the spread of the disease is due to soil infection which becomes apparent, especially in the progeny of plants grown in infected soil

2. CLIMATIC INFLUENCES AS AN IMPORTANT FACTOR IN THE PRODUCTION OF LEAF-ROLL

In 1914, investigations were started in Bermuda with a view to discovering the cause of the serious leaf-roll losses referred to earlier.

Overwhelming evidence was readily obtained, on visiting Nova Scotia and Long Island, that the immediate cause of the losses in Bermuda was the importation of strains of seed potatoes that were affected with leaf-roll before they were shipped to the colony.

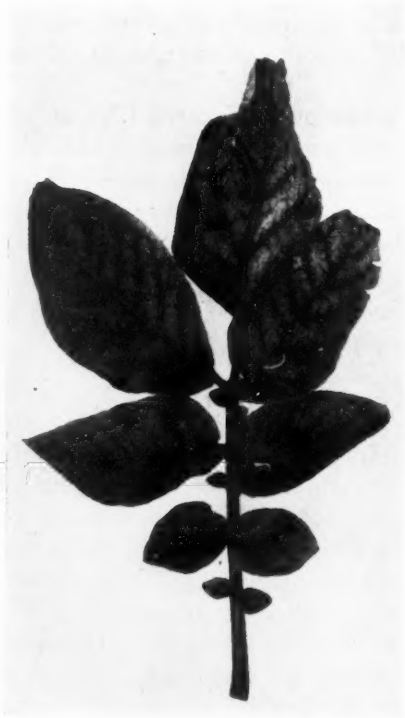


FIG. 9. LOWER LEAF OF PLANT OF BLISS TRIUMPH AFFECTED BY LEAF-ROLL

The apical and the upper axillary leaflet on the right show the yellowish discoloration characteristic of leaf-roll. The illustration also gives some impression of the rigidity of the leaf.

From a commercial standpoint, the institution of field inspection in the districts from which seed potatoes were imported and the avoidance of weak strains offered a means of protection. This, however, left the larger question of the original cause unsolved, and experiments were inaugurated for the purpose of throwing light on this very important and interesting aspect of the subject.

The work done has led to the conclusion that climatic influences play an important part in the development of leaf-roll. For example, a strain of potatoes may be grown for years in a district ideally suited to the potato, as in Aroostook County, Maine, and leaf-roll will be practically absent; on the other hand, if a portion of the same strain be taken to Bermuda or Long Island and planted for several seasons an appreciable percentage will develop.

Judging from the literature available, this reason for the appearance of leaf-roll has not before been definitely brought forward, and the observations and experiments that have led to this conclusion are, therefore, dealt with in some detail under the following headings:

1. The influence of drought on strains of Bliss Triumphs at the Agricultural Station, Bermuda.

2. The appearance of leaf-roll in Bliss Triumphs replanted for several seasons in Bermuda.

3. Leaf-roll in strains of potatoes obtained from Ottawa compared with the same strains from New Brunswick.

4. Leaf-roll in northern stock planted a third year on Long Island.

FIG. 10. LEFT, CHILI GARNET, BERMUDA AFFECTED BY LEAF-ROLL, ONE LEAF ONLY SHOWS DEFINITE SYMPTOMS. RIGHT, IRISH COBBLER, LONG ISLAND, AFFECTED BY LEAF-ROLL, ALL THE LOWER LEAVES SHOW CONSPICUOUS ROLLING

(*a*) *The influence of drought on strains of Bliss Triumphs at the Agricultural Station in Bermuda in 1914*

The first definite evidence that pointed to leaf-roll being due to climatic conditions was obtained as a result of an experiment conducted in 1914 at the Agricultural Station in Bermuda. Plants subjected to very severe drought and heat conditions gave tubers that when replanted produced 45 per cent of leaf-roll, while the progeny of the same strains planted in shade and consequently far less affected by drought, showed only 10 per cent of leaf-roll when replanted side by side with tubers from the drought-affected stock.

It is important to bear in mind that the experiment was conducted with potatoes that had been previously grown in Maine in 1912 on Long Island in 1913, and in Bermuda in 1913. Other experiments show that the

growth on Long Island and in Bermuda in the two preceding seasons, doubtless had a contributory effect.

In the experiment, the plantings were made in April, 1914. Four different strains of Bliss were each divided into two lots. Half of each was planted in a plot that suffered very severely from drought and a very small yield was obtained. The other half was planted in a field that was partly shaded and where the prevailing drought was far less felt, as evidenced by the growth of the plants and by the yield that was fair for the season of the year.

The crops were harvested in July, were kept separate, and were planted in October in neighboring plots. The plants were closely examined during the growing season and counts were made with the following striking results:

STRAIN	FROM DROUGHT AFFECTED PLOT		FROM SHADED PLOT	
	Normal	Leaf-roll	Normal	Leaf-roll
A	49	41	163	18
B	27	31	138	17
C	60	37	43	6
D	25	23	80	7
Total	161	132	424	48

Several check rows of stock imported that year from Long Island showed 2 to 3 per cent of leaf-roll.

In view of the different views that have been held as to the cause of the disease, it would not be reasonable to assume that this single experiment afforded positive proof of the effect of climatic conditions, and in this case of drought in particular, but it must be conceded that the uniform behavior of the four strains is most suggestive and, when supported, as it is, by the experiments recorded later, there would appear to be little room for doubting that unfavorable climatic conditions in the previous season, or seasons, are an important factor in the development of leaf-roll.

(*b*) *The appearance of leaf-roll in Bliss Triumphs replanted for several seasons in Bermuda*

In the fall of 1914 it was observed in Bermuda that a number of farmers who had used stock that had previously been grown in Maine, once in Long Island, and twice in Bermuda, lost considerable sums of money owing to the presence of leaf-roll. Neighboring fields planted with potatoes

recently imported from Long Island were free of the trouble and farmers were consequently cautioned by the Department not to replant for seed purposes potatoes received from Long Island.

Little, however, was definitely known on the subject and the obscurity of the origin of the Long Island stock made it impossible to draw reliable conclusions until more specific data could be secured. Reorganization of the seed trade, as a result of legislative measures put into force by the Bermuda Government, made this possible during the following year. It then became practicable to watch in Maine, Long Island, and Bermuda the behavior of a special strain of seed potatoes, the history of which could be accurately traced.

As a result, it has been proved that stock grown first in Maine; planted once on Long Island, and once in Bermuda will be free of leaf-roll and will produce good results, but if the stock be replanted a second time in Bermuda leaf-roll invariably appears in serious quantity.

FIG. 11. ROLL IN UPPER LEAVES OF A PLANT THE STOLONS AND ROOTS OF WHICH WERE AFFECTED BY RHIZOCTONIA

For example, a strain of Bliss, practically free of leaf-roll was selected in Maine in 1914 by Dr. I. E. Melhus and the writer as the most promising obtainable for seed purposes. Arrangements were made for the purchase of this stock by Long Island merchants interested in the Bermuda trade, and it was planted in April, 1915, on twenty-four farms near Riverhead, Long Island. In July, 1915, the farms were inspected during the growing season by Mr. H. C. Sands, Pathologist of the New York State Department of Agriculture, and the writer. Less than 1 per cent of leaf-roll was found.

In September and October of the same year, over twelve hundred barrels of potatoes obtained from the twenty-four farms were planted in Bermuda. A large number of the fields were inspected and 2 to 3 per cent of leaf-roll was observed.

The farmers were loud in their praise of the stock and claimed that it was the best that they had planted for years. So satisfied were they with it that a number replanted some of it in March and April of 1916 for the purpose of obtaining seed for the fall crop of the same year. In June ten farms with these potatoes were visited and in each case from 30 to 50 per cent of leaf-roll was found. In addition, a survey was made by field inspectors of practically all the farms on which the Maine-Long Island-Bermuda stock had been replanted and not a single field was found without a considerable percentage of leaf-roll.

FIG. 12. THE DEVELOPMENT OF LEAF-ROLL IN BERMUDA

On the left, Maine-Long Island stock with no leaf-roll present. On the right, Maine-Long Island-Bermuda-Bermuda stock showing 80 per cent of leaf-roll. Both originally the same strain. Photo by H. B. Shaw.

In marked contrast was the behavior of two hundred barrels of seed potatoes of the same strain imported, direct from Maine and planted at the same time in Bermuda. In no case was more than a very small percentage of leaf-roll discovered, although it was frequently planted on the same farm and often in the same field with the Maine-Long Island-Bermuda stock. Rows of strains originally the same, although no further apart than 24 inches, would show in the one case 2 to 3 per cent of leaf-roll and in the other case as much as 40 per cent. A striking case was seen on the farm of Mr. W. A. Moore in Paget.

The farmers were strongly advised not to replant this stock, which could be described as Maine-Long Island-Bermuda-Bermuda, and the majority abandoned it, but a few, owing partly to lack of seed and partly to lack of faith, replanted it in the fall of 1916. As was anticipated, disastrous results followed owing to the development of an increased percentage of leaf-roll, amounting in some cases to 80 per cent.

Three interesting cases may be cited:

1. Mr. John Simons, a farmer in Southampton, planted in September, fifteen barrels of the Maine-Long Island-Bermuda seed and one barrel of

FIG. 13. POTATO LEAF-ROLL AGRICULTURAL STATION, BERMUDA

On the left Maine-Long Island stock. On the right originally the same strain, but stock planted for four seasons in Bermuda and now showing 100 per cent leaf-roll.

Maine-Long Island stock. The difference between the two lots was very marked and the yellowish cast due to the large number of leaf-roll plants (40 per cent) in the former could be detected from a long distance.

2. A particularly interesting case was found on the farm of Mr. H. A. Peniston, M.C.P., who planted in the same field, Maine-Long Island stock, Maine-Bermuda, and Maine-Long Island-Bermuda-Bermuda, the last being placed between the other two. Forty-two per cent of leaf-roll plants were found in the Maine-Long Island-Bermuda-Bermuda and the most casual observer was able to detect where this stock joined the Maine-

Bermuda, one one side, and the Maine-Long Island on the other. Neither of the latter had any appreciable quantity of leaf-roll.

3. In a third case the Maine-Long Island-Bermuda-Bermuda seed was planted side by side with Maine-Long Island on the farm of Mr. George T. Miller. The former showed practically no leaf-roll and the latter had 80 per cent. A photograph of this field is shown in figure 12. Mr. Miller kindly supplied the following figures showing the yields of ten rows each of the two plots.

Stock	*Yield* barrels
Maine-Long Island	$2\frac{1}{2}$
Maine-Long Island-Bermuda-Bermuda	$1\frac{1}{3}$

FIG. 14. AGRICULTURAL STATION, BERMUDA

Strains on the left the progeny of stock grown previously at Ottawa. On the right the progeny of the same strains grown previously at Fredericton, New Brunswick.

(c) *Leaf-roll in strains of potatoes obtained from Ottawa compared with the same strains from Fredericton, New Brunswick*

Mr. W. T. Macoun (4), Horticulturist of the Dominion Department of Agriculture at Ottawa gives some very interesting figures showing the deterioration that took place in eleven varieties of potatoes grown at Ottawa during four seasons (1906–1909) in which the summer was hot and dry as compared with the behavior of the same varieties planted previously at Indian Head, Sask., under conditions favorable to the growth of the potato.

At the time that Mr. Macoun prepared his bulletin, the question of leaf-roll had not been brought clearly to the attention of potato workers on the American continent, and the deterioration observed by him was not at the time diagnosed as leaf-roll. The recorded behavior of the Ottawa stock, however, and the illustrations of the plants left little doubt

in the mind of the writer that the reported deterioration of the varieties was due to this disease.

Through the courtesy of Mr. Macoun, samples were obtained of the same strains of four varieties of potatoes from Ottawa and from Fredericton. The potatoes, in the case of each variety, had originally been the same strains, but one lot had been grown at Ottawa and the other at Fredericton, New Brunswick. Both sets of samples were planted in Bermuda in April, 1916. The Ottawa strains did very poorly and showed from 40 to 80 per cent of leaf-roll. This experiment determined that the deterioration referred to by Mr. Macoun was due to leaf-roll (see figs. 14 and 15), and supplies another link in the chain of evidence that unfavorable climatic conditions may develop leaf-roll in healthy strains.

FIG. 15. NEAR VIEW OF THE OTTAWA STOCK SHOWN IN FIGURE 14
Note erect, V-shaped growth of plants affected by leaf-roll on the left.

(d) Leaf-roll in northern stock replanted for two seasons on Long Island

In the course of field inspection work on Long Island a number of cases of leaf-roll have been observed, all pointing to the fact that the trouble had been developed by the replanting of stock for two or three years on the Island. In addition it was learnt from some of the most progressive and observant farmers that Maine stock could not be replanted for more than one or two years for fear of serious deterioration (fig. 16).

The most interesting case that came under my notice was on the farm of Mr. R. Hudson near Laurel, Long Island. In 1914 he obtained a strain of Green Mountains that was put on the market by a seed grower under a new name owing to its excellence. The first year it did extremely well on Long Island and was replanted in 1915. Again it did so well that the farmer was tempted to reserve some of it for seed. This he planted in 1916, making the third planting on the Island. The writer saw the field in June and found that it contained about 40 per cent of typical leaf-roll. A neighbouring field of Green Mountains imported direct from Maine was practically free of leaf-roll.

For three years I have visited Long Island and in only one instance has leaf-roll been found in stock imported the same year from Maine. In all other cases enquiry proved that stock found to be affected by leaf-roll was from seed planted for the third year on Long Island.

FIG. 16. LEAF-ROLL IN GREEN MOUNTAINS GROWN FOR THE THIRD SEASON ON LONG ISLAND

3. SOIL INFECTION NOT A FACTOR IN PRODUCING LEAF-ROLL IN BERMUDA

In view of the interesting data and arguments advanced by Quanjer in support of his claim that leaf-roll is largely due to soil infection, it is important that the writer should bring forward evidence to show that soil infection is not the cause of leaf-roll in Bermuda. Otherwise, students familiar with Quanjer's work might well assume that soil had played a part in the production of leaf-roll in the cases reported earlier and that this contingency had been overlooked and in consequence results attributed to unfavorable climatic conditions were in reality due to soil infection.

Seed potatoes have been annually imported for many years from the Cornwallis district in Nova Scotia, where a number of farmers have

retained leaf-roll strains year after year and there has been plenty of opportunity for fields in Bermuda to become infected. Many fields, for example, have been planted for two or three years consecutively with affected stock, but no matter how often a field has previously been planted with leaf roll stock, the disease does not appear if a healthy strain is afterwards planted in the same field.

At first the information gathered on this subject was of a general character, although very convincing, but during the last two years it has been possible to watch the matter more closely, and much specific data have been accumulated, proving beyond doubt that leaf roll in Bermuda in the first planting of imported stock is not due to soil infection.

For the past three years the regulations of the Bermuda Government have made it compulsory for Nova Scotia farmers to put their names on every barrel of seed potatoes shipped to Bermuda, and as each year the stock has been inspected when growing in Nova Scotia it has been possible to check the results in Bermuda. Until the present year it had not been possible to prevent the importation of all of the leaf-roll strains of Garnets, as only a limited number of farmers grew this variety of potato, and, if some of the less seriously affected strains had not been accepted, the result would have been a serious shortage of seed potatoes. From a commercial standpoint, the necessity for accepting these strains was much to be regretted, but from a scientific aspect, it has had its advantages, for valuable material has been obtained for purposes of study. If soil became infected after leaf-roll stock had been grown in it and produced leaf-roll the first season, the difficulties in the way of protecting Bermuda farmers would be insurmountable. Crop rotation is impossible, and, as a large number of fields have already been planted with leaf-roll strains, it would be reasonable to expect each year an increasing quantity of leaf-roll throughout the colony. As it is, by preventing the importation of affected strains practically no disease was found this year.

The following record of the behavior of five crops of potatoes on a field in Somerset illustrates the general experience of farmers in the Colony who have planted leaf-roll and healthy strains in successive seasons.

YEAR	VARIETY	SOURCES	CONDITION OF PARENTS AT FIELD INSPECTION	BEHAVIOR IN BERMUDA
1915	Garnets	Cornwallis, N. S.	Leaf-roll	Leaf-roll
1915	Bliss Triumph	Long Island	Healthy	Healthy
1916	Garnets	Cornwallis, N. S.	Leaf-roll	Leaf-roll
1916	Bliss Triumph	Long Island	Healthy	Healthy
1917	Garnets	Clifton, N. S.	Healthy	Healthy

The experience of farmers has been borne out at the Agricultural Station, where experimental work has been carried out on the same plots for four years. Two crops were planted each year and there were thus eight consecutive plantings in the same soil. In one season, leaf-roll will be present when a leaf-roll strain is planted. In the succeeding season, if healthy stock is planted in the identical plot, no leaf-roll will be found. The disease can always be anticipated from a knowledge of the strain.

In the preceding paragraphs it has been demonstrated that direct infection, visible the first season, does not occur in Bermuda as the result of growth in soil in which leaf-roll plants have previously been grown. Quanjer reports cases of such infection, but lays more stress on the development of leaf-roll in the *progeny* of plants grown in infected soil.

For some years past limited quantities of Bliss Triumphs have been imported into Bermuda direct from Maine and planted in the colony in March and April. The resulting crop has been retained for seed for planting in the early fall. The Maine stock has not infrequently been planted in soil in which leaf-roll strains were grown the season before, but field inspections since 1914 have shown that leaf-roll does not develop to a serious extent as a result of this treatment, indicating that under Bermuda conditions the progeny of stock that has been grown in soil that has had ample opportunity of becoming infected does not develop leaf-roll to an appreciable degree.

Experiments conducted on Prince Edward Island and reported by Murphy and the writer confirm Quanjer's work in so far as they prove that the progeny of healthy parents that have been grown near diseased plants develop leaf-roll.

ACKNOWLEDGMENTS

In conclusion, I desire to thank the many agricultural officers whom I have met in the United States and Canada for courtesies extended to me as representative of the Bermuda Department of Agriculture. In particular, I have to acknowledge my indebtedness to Dr. W. A. Orton, Pathologist in Charge of the Office of Cotton, Truck and Forage Crop Disease Investigations of the United States Department of Agriculture, to Mr. H. C. Sands, Pathologist of the New York State Department of Agriculture, and to Mr. P. A. Murphy, B.A., Pathologist of the Dominion Department of Agriculture for valuable assistance in improving the class of seed potatoes grown for Bermuda.

AGRICULTURAL EXPERIMENT STATION
BERMUDA

LITERATURE CITED

(1) ORTON, W. A. Potato wilt, leaf-roll, and related diseases. U. S. Dept. Agr. Bul. 64, 18–37, illus. 1914.

(2) APPEL, OTTO AND SCHLUMBERGER, OTTO. Die Blattrollkrankheit und unsere Kartoffelernten. Berlin, 102 p., illus., 3 pl. 1911. (Arbeiten, Deutsche Landwirtschafts-Gesellschaft, Heft 190.)

(3) QUANJER, H. M. Nature, mode of dissemination and control of phloem-necrosis (leaf-roll) and related diseases. Overgedrukt uit "Mededeelingen van de Riiks Hoogere Land, -en Boschbouschool" Deel X. 1916.

(4) MACOUN, W. T. In Annual Report on Experimental Farms, for the year ending March 31, 1910, Ottawa, Canada, Sessional Paper No. 16. 143–150. 1910.

VARIETIES OF BEANS SUSCEPTIBLE TO MOSAIC

DONALD REDDICK AND VERN B. STEWART

The mosaic disease of beans is very common in New York[1] and apparently is becoming generally distributed throughout the important bean-growing sections of the United States.[2] In connection with work on the disease the writers have had occasion to test the susceptibility to the disease of a number of the commoner varieties of *Phaseolus vulgaris* and of a few varieties of different antecedents.

The mosaic disease of beans is comparable in all important respects with the mosaic of tobacco, although the two have not proved intercommunicable. The most important difference thus far noted is that, whereas the mosaic of tobacco is not communicated through the seed, the mosaic of beans is so communicated. This difference, while perhaps not of great significance botanically, is of considerable importance in developing a practical means of control of the disease, in that there is strong presumptive evidence that seed selection is not likely to prove effective in the development of disease-free stock.

The evidence for this is not exhaustive but seems to be sufficiently clear to make it necessary that experiments in selection and rogueing be conducted before the method is even suggested to the grower. In early September 1916, one of us (R) participated in a trip through the field bean sections of New York to make selections of disease-free or disease-resistant plants, particularly with reference to root diseases. However, the mosaic disease was under investigation at that time and its symptoms were known to all members of the party. Several hundred selections of individual plants were made and the plants placed separately in cloth bags. The seeds were saved by number and were planted in 1917 in long rows the various selections being separated only by a stake. Seed from those selections made in fields where root diseases were not prevalent were planted at Ithaca. Prof. R. A. Emerson, of the department of Plant Breeding at Cornell University, who had charge of the work, noticed that many of the progenies showed mosaic and on looking over the records of the source of these diseased lots it appeared to him that the diseased plants came from selections made in sections where the mosaic was prevalent

[1] Stewart, V. B., and Reddick, Donald. Bean mosaic. (Abstract) Phytopath. **7:** 61. 1917.

[2] The plant disease bulletin, U. S. Dept. Agr. **1:** 8, 24, 42, 43. 1917; **2:** 22. 1918.

and that the disease-free lots came from selections made where the disease was either not present or was very rare. Seed from the plants thought to possess resistance to dry root rot (*Fusarium* sp.) were planted in Fusarium-infested soil at Perry, New York. Dr. W. H. Burkholder observed independently, the same condition noted by Professor Emerson. It is certain that the majority if not all of the original selections showed no symptom of the disease. Contributory to this is the fact that plants affected with the mosaic disease usually bear a reduced number of pods or none at all whereas the first consideration in making the selections was that the plant should have yielded well.

The writers have already tested many of the commoner ways in which these lots of seed might have become contaminated but as yet have only negative results. One important method is only now under test, namely that the infective principle is carried in the pollen of diseased plants and that plants so infected do not show typical symptoms of the disease but only show it in the progeny. The most important argument against the theory is the well-known fact that beans are largely selfed whereas this large number of diseased plants from random selections would indicate that cross fertilization was very common. However, it is true that cross pollination is of common occurrence and it is possible that pollen so carried might germinate and enter the style and infection might be effected in this way.

The whole question of insect carriers in connection with this disease remains to be clarified.

Evidence in favor of the idea that selection may prove practicable lies in the fact that, in infection experiments, healthy plants of susceptible varieties have stood touching diseased plants and have borne seeds which developed healthy plants. Seeds from diseased plants usually develop diseased plants to the extent of 50 per cent or more. In view of the above facts it seems obvious that the value of selection to secure disease-free seed must be determined by experiment. Rogueing at the time of the appearance of the first trifoliate leaf would seem *a priori* a more likely means of control.

The most satisfactory solution of disease control in a crop like beans lies in the development of a disease-resistant or immune strain. The Wells Red Kidney bean which is highly resistant to the strain of *Colletotrichum lindemuthianum* designated as *F* by Barrus[3] and immune to his strain *A*, was developed from a chance selection. From this Burkholder[4]

[3] Barrus, M. F. An anthracnose-resistant Red Kidney bean. Phytopath **5**: 303–307, figs. 1–4. 1915.

[4] Burkholder, Walter H. The production of an anthracnose-resistant White Marrow bean. Phytopath. **8**: 353–359. 1918.

has succeeded in developing, by hybridization, several types of field bean, particularly a White Marrow, which have the same characteristics with respect to anthracnose resistance as the Wells' Red Kidney. It is, of course, necessary to find, first, varieties or individuals which are immune or highly resistant to disease. These may prove valuable in themselves or may furnish the basis for the development of desirable types by hybridization. The following list of varieties tested by no means exhausts the possibilities but is worthy of publication at the present time because of the increasing prevalence of the mosaic disease, the abandonment of bean growing by many farmers and the enforced interest of pathologists in a practical solution of the problem of control of the mosaic disease. The names of varieties employed are those given preference by Jarvis.[5] Seeds of the various varieties were obtained from dealers by Dr. M. F. Barrus. They are, for the most part, true to name since Doctor Barrus has made special effort for a number of years to locate authentic sources of seed of the various varieties. The plants, usually twelve of each variety, were grown in pots in the greenhouse and a susceptible variety was always employed to serve as a check on the effectiveness of the inoculum. The inoculations were made by rolling together and crushing slightly a number of leaves from diseased plant and rubbing the under sides of the fully expanded juvenile leaves of the test plants. The rubbing was always vigorous enough to injure the leaves of the plants. In most cases the inoculated plants were placed in a moist chamber for 24 hours but this is not necessary and was not always done.

It has happened many times that all the plants of a given variety inoculated did not develop the disease. This happens also with a variety which is highly susceptible. It is not regarded as a sign of resistance or immunity in the individual, only a baffling weakness in technique due to ignorance of the fundamental nature of the infective principle.

The following varieties of *Phaseolus vulgaris* have shown unmistakable symptoms of mosaic from inoculation: Challenge Black Wax, Currie, Davis, Golden Wax, White Imperial, Hodson Wax, Refugee Wax, Scarlet Flageolet, Wardell, Black Valentine, Burpee Stringless, Canadian Wonder, Hodson Green Pod, Lady Washington, Navy Pea, Red Kidney, Wells' Red Kidney, Red Valentine, Refugee, Ruby Horticultural, Tennessee Green Pod, Turtle Soup, Warren, White Kidney, Yellow Eye, Yellow Six Weeks, London Horticultural, Michigan White Wax, and Blue Pod Medium. The list is by no means exhaustive but includes a number of the better-known varieties.

[5] Jarvis, C. D. American varieties of beans. Cornell Univ. Agr. Exp. Sta. Bul. 260. 1908.

The following varieties, which have been subjected to a single test, did not develop the mosaic: Detroit, China Red Eye, Arlington Red Cranberry, Creaseback, White Runner. They along with a number of other varieties not mentioned here are now under test.

Of the shell or field beans, the White Marrow has been tested a number of times but with uncertain results. It does not show typical mosaic in the field nor on inoculation. Inoculated plants, however, often show a peculiar mottling which has the appearance of a suppressed case of the disease. Such leaves have been used for inoculating a susceptible variety and in one instance two plants out of ten inoculated developed typical mosaic after the usual period of incubation. The White Marrow is apparently either immune or highly resistant. In Marrow bean fields one finds here and there a bean of the marrow type but which is later in maturing and the seeds of which are somewhat flat. The type is well known to bean growers who refer to it as a bastard bean. It exhibits numerous variations but all agree in marked susceptibility to mosaic. For this reason a mixed lot of seed of the type has been used to furnish plants for a check on the potency of the inoculum in the infection experiments.

Burlingame, often referred to as York State Medium or Medium, has been tested and found susceptible. In the field it is affected almost to the same extent as Pea.

Pea beans are the ones most affected both from the standpoint of distribution and of severity of the attack. Fields of Pea beans have been seen repeatedly where more than half the plants showed the symptoms of mosaic. Near Caledonia, New York, Pea beans are grown extensively and in early September, 1916, several growers experienced a total failure and plowed under their beans for a soiling crop. One of the writers (R) in company with four other men spent about 20 minutes in a field of perhaps 30 acres in this neighborhood where nearly every plant apparently had the disease. The four men took every plant they found which had any pods on it. The number of plants thus selected did not exceed 25. It is practically certain that mosaic was not entirely responsible for this complete failure to set pods, since dry root rot was unusually abundant in the field, but it is true that mosaic diseased plants set a reduced number of pods or none at all.

Pea beans brought in from other States for trial by farmers in certain instances have been found free from the disease even when grown in the same field with badly diseased plants from home-grown seed. It seems that this is accounted for readily by the fact that that the foreign seed came from a section where the disease did not exist. The same explanation was at first offered when Prof. R. A. Emerson noted that one of his

strains under test (No. 1986) was free from the disease, even in the midst of diseased plants. The strain continued free from mosaic for three years. The writers have tested it repeatedly by inoculation in the greenhouse and it has never shown any symptoms of the disease. Dr. C. W. Edgerton, Baton Rouge, Louisiana, and Dr. C. D. Sherbakoff, Gainesville, Florida, also have kindly tested small lots of this variety and find it immune. On examining the record it is found that this number represents a lot of seed secured from Professor Spragg of the Michigan Agricultural College and that it came originally from an individual plant selected by him in 1908. It is now known as the variety Robust. Spragg states[6] that in variety tests Robust has given the highest yields of any of his extensive collection grown at East Lansing. The variety in common with other Pea beans is susceptible to anthracnose. In view of Burkholder's success, however, it is possible that resistance to the anthracnose may be introduced by hybridizing with Wells' Red Kidney or better with Burkholder's White Marrow (Wells' Red Kidney is susceptible to mosaic; Burkholder's White Marrow has not been tested).

Professor Spragg, in a letter, states that Robust may be distinguished as follows: "The Robust holds its leaves more extensively during the summer. A month before maturity the Robust will be found with such a heavy green foliage that anyone examining the variety series would say without question that this is the latest bean in the series. As time proceeds we find that the foliage of the Robust gradually turns yellow and within a week is dropped completely. The other varieties lose their leaves more or less all summer, turning yellow in patches, due perhaps to disease conditions, and at pulling time one almost invariable finds a good supply of scattered green leaves." Professor Emerson states in a letter that "in our yield tests 1986 (Robust) has yielded from 20 to 50 per cent more than common pea beans and has been noteworthy for uniformity in ripening, holding pods well off the ground, and so forth."

CORNELL UNIVERSITY
ITHACA, NEW YORK

[6] Spragg, Frank A. Report of crops breeder. Rept. Mich. State Bd. Agr. **1916**: 200. 1916.

BRIEFER ARTICLES

TWO TOMATO DISEASES[1]

ERNEST SHAW REYNOLDS

During the winter of 1913–1914 two diseases of a greenhouse tomato crop appeared. The first, a chlorosis of the leaf, was apparently of small importance from a commercial point of view. The second, a fruit rot, was responsible for practically a total failure of the crop. The tomato plants were of the variety known as the Bonny Best, and at the time the writer's attention was first called to them, during the last days of December, the plants were about a foot high. They were cultivated in the ordinary way having been transplanted from boxes to the beds some time previous to the beginning of the winter's observations. The plants, over one hundred and fifty, were planted in two beds, one containing thirty-two being along the west wall of the greenhouse, and the other containing the remainder of the plants being in the center of the greenhouse.

TOMATO LEAF CHLOROSIS

Observations and experiments

When observations first began, about fifty-five plants showed at least two leaves in a partially chlorotic condition and others showed one leaf so diseased. Nearly all of the plants in the west wall bed and a considerable number through the center of the middle bed showed the disease, while the plants toward one end of the middle bed were entirely free from the trouble. In about half of the fifty-five mentioned three or four leaves were affected, often involving over half of the total number of leaflets. After the first of January few additional plants showed the disease and on the plants already diseased the new leaves did not generally become affected. As the plants matured the new leaves remained free from the chlorotic appearance, though in a few cases the midrib of one or more leaflets became distorted in the manner to be described for the typical disease. The diseased leaves in many cases finally dried up due to the complete interruption of the normal functions by the chlorotic condition. Some of the less diseased leaves remained functional, except for the chlorotic areas, until finally removed in the regular horticultural work.

[1] Transmission No. 1 from the Botanical Laboratories, N. D. Agricultural College.

The characteristics of the disease were as follows. The typically severe condition was that of completely whitened areas gradually or often abruptly passing into the normal green of the leaves. The whitening usually was not preceded by a yellowing though in a few doubtful cases it appeared that there may be a fleeting yellowed condition. Where progressive whitening occurred, thus increasing the size of the white areas, almost no yellowing was seen. On a few plants leaves were seen with yellowish areas or yellow spots but these never developed with the white areas. The white areas often extended in the mesophyll next to the veins, but in most cases the veins themselves remained green until the white areas nearly lost their chlorophyll but later the areas became translucent and parchment like having the appearance and texture of completely dried tissue. The center of the leaflet along the midrib was almost universally the portion first affected; and very commonly the terminal leaflet and the leaflets upon one side of the rhachis were those most diseased. Figure 1 is a photograph of a typically chlorotic leaf showing the features described above. The whitened areas are faithfully reproduced, and are seen to be irregularly placed and greatly variable in size. Usually in connection with this chlorotic condition the midrib, at its center or at least about opposite the center of the diseased area, became enlarged and apparently by excessive growth at that point became strongly bent backward. In other cases the half of the leaflet most strongly diseased grew more slowly or not at all with the result that the whole leaflet become arcuate. This condition is shown in the left hand second and fourth leaflets of figure 1. One further defor-

FIG. 1. TOMATO LEAF CHLOROSIS

The white areas were white in the living leaf. The two larger left hand leaflets show the arcuate condition of many diseased leaflets.

mation was noticed. The halves of the diseased leaflet often became strongly bent downward toward one another as if the upper surface of the leaf had enlarged while the lower surface had ceased to grow. The line of bending was along the midrib.

Several attempts were made to induce the disease by cutting back the plants so as to force a rapid growth from the lower portion of the stem. No whitening occurred, though in some leaves a yellowing followed this treatment. Solutions of various iron salts were painted upon the whitened areas, also with negative results. Portions of the typically diseased areas, but still soft and juicy, were cut from the leaves and rubbed upon healthy leaves. Diseased leaves were freely handled and then healthy leaves were immediately touched. In both of these sets of experiments, in which it was attempted to inoculate young and old leaves from diseased areas, the results were negative.

Discussion and conclusions

After a careful comparison of the characteristics of the chlorotic disease described above and the mosaic disease as described by various writers it seems clear that the one now described is probably a newly described trouble or possibly a very aggravated condition of the mosaic trouble. It is certain that as ordinarily described the mosaic disease is a yellow and green mottling. Melchers (2) has carefully summarized the status of the mosaic problem up to the date of his article, and in none of the earlier writings is there a reference to white areas being found in the leaves affected with mosaic. The fact that in none of the accounts since Melchers' paper, so far as they have come to the writer's attention, is there reference to this characteristic, indicates strongly the clear distinction between these diseases. Since also no mosaic characteristics preceded the chlorotic disease it seems clear that they are not related. Undue emphasis should not be placed on the fact that there was a distortion of the diseased leaves similar to that described by various authors, as for example Allard (1) for that would at best merely indicate a "generic" relationship between diseases. In fact it would appear from the work so far done on the so called "mosaic" disease that two or three different diseases, related generically, are included under that convenient term. We may conclude therefore that this Tomato Leaf Chlorosis is a newly described disease.[2]

The cause of this disease at present may be only surmised. No organisms of either insect, bacterial or fungous nature have been found connected

[2] The horticulturist in charge of the greenhouse assured me that there had been no fumigation in the house during the fall of 1913. It is to be noted also that the peculiar distribution of the disease in the beds would be hard to account for on the basis of fumigation.

with the diseased areas. The lack of an infectious or contagious characteristic would argue against a parasitic cause. However it should be clear that negative results in such matters are necessarily tentative. The final disappearance of the disease with the removal of the lower four or five leaves also indicates the non-parasitic nature of the trouble. Other tomato plants growing in the same house, though not in the same beds, after the first crop began to mature did not become diseased. A considerable number of cucumber plants showed leaves with white areas though these were more regular in outline than those on tomato leaves, at the same time as the tomatoes. From these and other observations noted, the writer is inclined strongly to attribute the disease to some unknown environmental conditions surrounding the plants when the leaves that became diseased were in a very young or embyronic condition. That the plants responded to these conditions by the over or under production of some enzyme is possible. In fact it would appear to the writer that a classification of diseases which separates enzymic disturbances from "physiologic" is completely unnatural.

BLOSSOM END ROT

Observations and experiments

About the middle of February when the tomatoes began to fruit the writer's attention was called to a "rotting" of the young fruit. Every plant of the crop under consideration had some fruits destroyed by this trouble and in the majority of cases all of the fruits were thus injured. The disease was characterized by a darkening of the fruit at the blossom end. Usually this dark color was solid and almost exactly circular in outline. The flesh remained hard and the skin unbroken. In a relatively few cases the diseased area was spotted with dark, closely set spots not over three millimeters in diameter and usually smaller than that. Along with the spots there was at times a slight darkening of the entire diseased area. The typical conditions and the spotted appearance are both shown in figure 2, the single upper tomato illustrating the spotted appearance, the left hand specimen showing the advanced stage of the disease, and the third the usual condition in a medium sized fruit.[3] The disease in nearly all cases began with the setting of the fruit, or at least very soon after, for the smallest fruits were usually affected. In a few instances the disease did not appear until the fruit had developed somewhat, when it appeared

[3] Since the winter when the records of these two diseases were made, several accounts of the Blossom End Rot have been published, but it will be well to report such symptoms as were observed by the writer in view of the discussion to follow.

as the mottling or spotting mentioned above. As the fruit enlarged the diseased spot enlarged also, developing at the rate of development of the fruit until the fruit began to turn red when the disease spread no farther. In a few specimens as much as half of the fruit was involved in the disease, but never did it exceed that amount and usually not over a third was diseased. The discolored zone was most frequently clearly marked off from the healthy tissue by a darker line and in all cases except the mottled fruit the injured tissue was sharply in contrast with the normal. Very commonly the ripening of the fruit proceeded toward the stem from the bound-

FIG. 2. BLOSSOM END ROT

The smaller upper fruit shows the mottled condition. The one at the right is in medium condition and at the left the advanced, velvety, olive-green, somewhat shrunken condition is illustrated.

ary of the diseased tissue. The typically diseased areas never turned red nor did they soften except where, as in one or two instances, some soft rot organism gained entrance. Rarely in the mottled fruit practically the entire fruit became red, though even in these instances the small spots often retained a greenish hue. In very slightly diseased fruits the final appearance was a slight scurfiness under the skin. A few of the most seriously diseased fruits had a slight concentric development resulting in indistinct rings; and for a considerable portion of the time the diseased portion had a dark olive-green, velvety appearance. A later crop of tomatoes in the same and another greenhouse did not produce any diseased fruit.

Experiments were made attempting to discover some causative organism, but with negative results. Several organisms were isolated but none of these could be induced to produce the blossom end rot on the partly developed fruit then available.[4]

Discussion and conclusions

Many of the conditions under which this type of disease may develop have been studied and described by Brooks (3) as well as by other workers. These have assigned various agencies as possible causes of the diseased condition called blossom end rot. When one places side by side the descriptions from these various sources a considerable number of discrepancies appear which, associated with the various assigned causes, leads one to question whether all these "rots" are really the same disease. The coincidence of location on the fruit and certain general characteristics may perhaps blind us to the *specific* differences. Added to these there are also manifestly incomplete descriptions and different usages of words sufficient to hide the real possible specific differences. It would not be surprising to find that several different and independent causes acting upon a uniform tissue, such as that of a green tomato, produce results of *generic* similarity and hence give rise to a group of diseases all at present included under one name. We have not perhaps considered deeply enough the influence which the host tissue may have upon the characteristics of a disease. Too often the symptoms are considered as due to the organisms rather then as a reaction of the host to parasitic invasion. When the tissue is fairly uniform we may then expect to find that any one of several organisms may cause very similar symptoms with the result that we diagnose the disease as due to one specific organism when it may be due to another. This may in time be found to account for a number of cases where different students have described, what has been called the same disease, as having somewhat different symptoms. In other words in several cases at least one name may cover a group of similar diseases and hence is generic in value rather then specific. This condition has been revealed in connection with the leaf-roll diseases of the potato and may be suspected in other cases. Those who have assigned "physiological causes" as the sole reason for blossom end rot have not completed the circle of evidence since exclusion of parasites from the experimental plants seems not to have been accomplished. The results of their experiments have established that the

[4] Since the epidemic described the writer has not been able to follow up these observations with other experimental work, but submits the following discussion hoping others working upon this disease may be able to determine the real cause of the disease.

disease is greatly *increased* or *decreased* by environmental conditions, which might be equally true for diseases caused by parasites, or simply by changes of environment. On the other hand, apparently successful inoculation experiments have given rise to diseases sufficiently like blossom end rot to at least be confused with one another and it. One possible source of infection however seems to have been neglected in the study of this type of disease.

In the greenhouse it is a rule to cross pollinate tomato plants to ensure profitable returns and in this process the transfer of bacteria or even fungous spores from plant to plant would be easy. This idea was forced upon the writer by the universality of the disease in both beds of the greenhouse and upon every plant. The method of pollination was to use a dish and brush and there was no sterilization of the apparatus. That bacteria possibly enter the stigma at time of pollination seems a reasonable assumption from the fact that almost all of the fruits were diseased from the younger stages of development. The conditions in the greenhouse were varied considerably without a cessation of the epidemic, which may have been due to the very effective transfer of infective material. The Bonny Best variety is given as very resistant to the disease, at least under the conditions in Brooks's experiments, yet it was this variety which was the exclusive one growing in the greenhouse. A later crop partly in this greenhouse did not develop the disease, possibly because there were no diseased plants from which an epidemic could start or possibly because of materially changed conditions. It is evident now from all pathological investigations that a disease develops only when both the causative organism (if there is one) and favorable conditions coincide.

It is quite possible that the inability to produce the disease by inoculation has been because the attempt has not been made at pollination time. It is even possible that the causative organism will infect only at that time even if it can continue to develop in the maturing fruit. From a large amount of cultural evidence it is becoming more and more apparent to the writer that organisms have a remarkable ability to become "acclimated" to environmental conditions. The ability to *infect* a host must be considered as definitely different from the ability to *spread* in the host tissues, especially when, as in a developing fruit, the chemical and physical conditions are changing. We may account for the observation that in some cases the disease shows only after the fruit has enlarged somewhat, by suggesting that the organism must become adjusted to its environment before it can extend into the tissue far enough to cause characteristic symptoms of the disease. Modified climatic factors no doubt would influence the rate of this adjustment. The absence of positive recognition of bacteria in diseased fruits should not militate against the possibility

of the disease being due to some organism, since we have strong evidence that ultra microscopic organisms exist and cause disease.

The hypothesis proposed here then may be summarized as follows; that the diseased condition known as blossom end rot of tomatoes, and showing the symptoms described and illustrated above, is due to an organism, probably ultra microscopic, which infects at pollination time only and causes the rotting area to enlarge until such time as the physiological processes of maturing the fruit have changed the composition of the fruit so much that further invading of the tomato tissue is impossible for the organism.

AGRICULTURAL COLLEGE
NORTH DAKOTA

LITERATURE CITED

(1) ALLARD, H. A. The mosaic disease of tomatoes and petunias. Phytopath. **6**: 328–335. 1916.
(2) MELCHERS, L. E. The mosaic disease of the tomato and related plants. The Ohio Naturalist **13**: 149–173. 1913.
(3) BROOKS, CHARLES Blossom-end rot of tomatoes. Phytopath. **4**: 345–373. 1914.

AN AUTOMATIC SPORE TRAP

F. D. FROMME

Various types of spore traps have been used in studies of the aerial dissemination of fungous spores; dishes containing water, agar, or gelatin, coated glass plates, etc. Records have been obtained by exposing the trap for a stated period and the number and kind of spores caught determined by direct microscopic examination or incubation on a suitable medium. Where exact records for any considerable period are desired, frequent change of traps is necessary. This is time-consuming and often, during the night or in inclement weather, disagreeable. An automatic spore trap which would register the periodic dissemination of spores with infrequent visits from the operator would be a valuable addition to the equipment of the phytopathologist.

The trap described herewith has been used with some success by the writer. The idea is presented in the hope that it may prove of service and may lead to the development of a thoroughly satisfactory trap.

Two views of the trap are shown in figure 1. A "Big-Ben" alarm clock is used as a carrier for one-half of a Petri dish containing non-nutrient agar. A light metal piece with six arms, the ends of which are turned up to clasp the edge of the dish and hold it in place, is attached to the shaft of the hour hand and a revolution of the dish in twelve hours is thus provided.

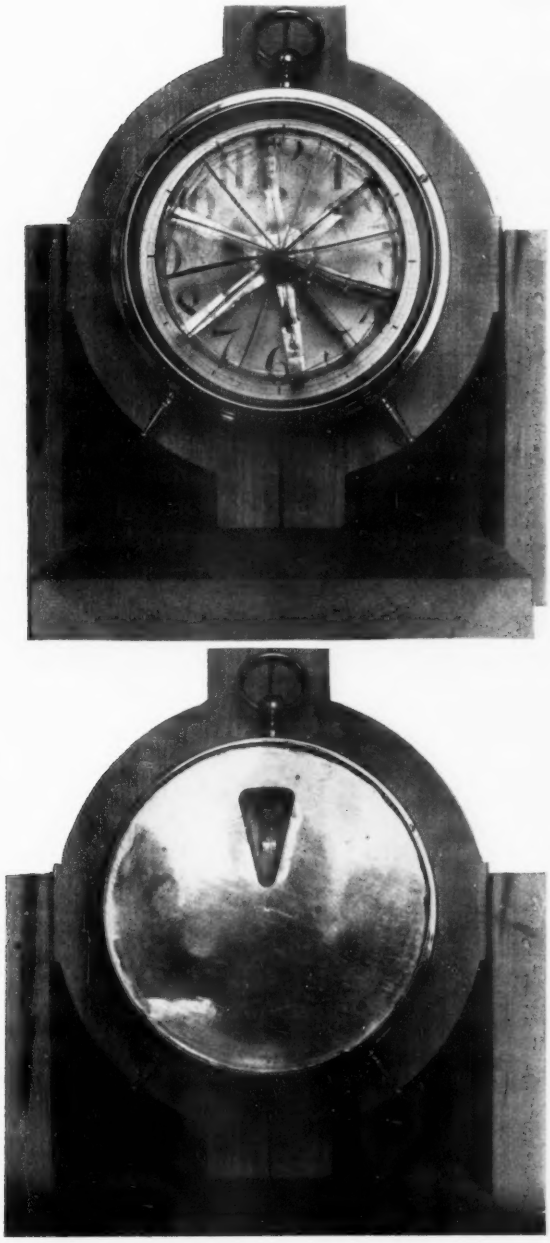


FIG. 1. TWO VIEWS OF THE AUTOMATIC SPORE TRAP
The cover is removed above to show the Petri dish in position.

A metal cover, which fits over the rim of the clock case, has an aperture which exposes a sector equivalent to one-twelfth of the area of the dish and to an hour's time in operation. A frame work of thin metal strips set on edge, in the manner of a paddle-wheel, is forced into the solidified agar in the dish and divides its area into twelve sectors. The strips are of the same height as the dish and prevent, in a large measure, the sifting about of spores, the clearance between the cover and the dish being reduced as much as possible. The clock is mounted in a wooden frame and is pivoted in two upright pieces at the sides so that the face may be exposed at any angle. The clock mechanism carries this load with no apparent strain.

In operation a mark on the edge of the dish indicates the starting point, the sector first exposed, and a record of the time is made on the back of the dish with a crayon. While the accuracy of the apparatus is not absolute, a very fair record of spore dissemination may be obtained. The main difficulty lies in the fact that the rotation of a plate is continuous and two sectors are exposed during an hour. This could of course be obviated if an intermittant mechanism were provided.

The trap has been used in a study of the dissemination of basidiospores of the cedar rust fungus, *Gymnosporangium juniperi-virginianae*. The following data shows the record obtained in one exposure.

May 16. Rainfall began at 5.30 p.m. and continued with some intermissions until 9.30, 0.57 inches falling during this period. A light rain began at 10.00 p.m., its discontinuance was not observed, but only 0.05 inches had fallen at 5.00 the next morning. The cedar galls were swollen and gelatinous at 7.30 p.m. The spore trap was exposed at this time at a distance of 100 feet from the cedars with a shelter to prevent rain from falling on the face. A Petri dish was exposed under the cedars at the same time, and no basidiospores were found on it at 10.00 p.m.. An examination of the dish in the trap at 5.00 the next morning showed about two basidiospores to each microscopic field from 10.30 to 11.30 p.m., with an occasional basidiospore from then until 5.00 a.m. The open dish which has been exposed under the cedars during the night showed an average of three or four basidiospores per field at this time. A clean plate exposed at 5.00 a.m. showed no spore discharge at 5.30 a.m.

A STERIGMATOCYSTIS SMUT OF FIGS

ROBERT W. HODGSON

For a number of years growers of White Adriatic figs in California have experienced losses due to a black discoloration which is found in a certain portion of the crop. This trouble has come to be known as "black smut" by fig men, and so far as the writer has been able to ascertain, has never received any considerable investigation. During the last six months, this trouble has been studied by the Division of Citriculture of the State College of Agriculture. Although the investigation is by no means completed, it is deemed best to publish the results at this time because of the fact that the present war emergency has necessitated the discontinuance of this work indefinitely.

A cursory survey of several Fresno packing houses as to the per cent of infection has revealed the fact that ordinarily 3 to 10 per cent of the figs are infected and occasionally as high as 15 to 25 per cent. Badly infected figs can be readily told by the discoloration of the outer skin and when opened, such figs exhibit a dark powdery mass of fungus spores. Cultures made from such figs have uniformly resulted in a Sterigmatocystis. The per cent of badly infected figs is relatively small and these figs can be easily sorted out and discarded. There is, however, a much larger percentage of the figs which is infected to only a slight extent. When opened, these figs show a streak or two of a blackish gummy nature, which detracts greatly from the golden color of the pulp. The presence of this black gummy mass in small quantities does not injure the flavor of the pulp and such figs can be used to advantage in the manufacture of fig paste for confectionery use. The exasperating feature lies in the difficulty in detecting these figs; some inevitably reach the consumer, greatly to the detriment of the industry.

Microscopic examination of these dark colored masses seldom reveals any spores or even recognizable traces of the fungus mycelium. Cultures from such material, however, in practically every case have yielded a Sterigmatocystis. The uniformity with which we have isolated this Sterigmatocystis in the large number of cultures made from figs exhibiting varying stages of infection has led us to believe that this fungus is the causal organism. A few other common fungi have occasionally been recovered in our cultures, but in every culture we have uniformly recovered a single type of Sterigmatocystis.

An interesting fact brought out in this investigation is that this fungus is apparently the same as that reported by MacMurran (1), as causing an internal rot of pomegranates. An investigation of pomegranate diseases which was being prosecuted in our laboratories at the same time and will

be reported on later, afforded opportunity for careful comparison of the two strains of Sterigmatocystis. Pomegranates infected with an internal Sterigmatocystis rot were obtained from Indio, where T. F. Kearney reported it in 1910. A large series of cultures were made from these infected fruits and kept running over a period of several seasons. These cultures were run in parallel series with those obtained from black smut figs. Careful microscopic examination has so far not revealed any differences in the two strains. Moreover, a number of inoculations of the fig smut strain into sterilized healthy pomegranates have shown cultural characteristics in every way similar to those obtained from the use of the pomegranate strains. Although not enough cultural work has been done to make these findings absolute, the writer is convinced that the two strains are the same

As to the time and manner of infection, very little definite knowledge is at hand. The fig, on account of its high sugar content and peculiar structure, permitting the entrance of small insects, is particularly subject to visitation by numerous small insects which not only carry black smut spores but ferment producing organisms as well. The White Adriatic fig is particularly subject to souring caused by the latter organisms. It seems probable that those figs which are badly infected with black smut, and which show the interior as a black powdery mass, are infected while still on the tree. However, the writer is led to believe that those slightly infected figs which are so hard to detect are infected by small beetles crawling into the eyes of the figs after they have fallen to the ground. At this time, the figs are rapidly decreasing in water content with a consequent increase in the per cent of sugar which inhibits the growth of the fungus before it has gone very far. The prevailing practice in the handling of dried figs is to allow the figs to remain on the ground for a period of ten days to two weeks, which certainly furnishes ample opportunity for the entrance of small beetles and other insects. The writer is therefore led to believe that gathering the figs at shorter intervals than is now practiced, which will also result in a much better dried fig, will prevent at least a certain amount of black smut.

CITRICULTURE RESEARCH LABORATORY
UNIVERSITY OF CALIFORNIA

LITERATURE CITED

(1) MACMURRAN, S. M. A new internal rot of pomegranate. Phytopathology **2**: 125-26. 1912.

A STORAGE FERMENTATION OF DASHEENS

ORVILLE TURNER WILSON

Early in 1918 the department of botany of the University of Cincinnati received, through the courtesy of the United States Department of Agriculture, a small consignment of dasheen tubers and corms. One of the latter, upon being cut, was found to be rotted in a peculiar way. The tissue was of the consistency and appearance of a moist commercial yeast culture such as is sold wrapped in tin foil. As compared with normal dasheen tissue it was dull in appearance and showed a tendency to crumble under the knife. There was present a marked odor of fermentation suggesting the presence of yeast. Isolation cultures plated on agar from the infected tissues showed yeast colonies almost to the entire exclusion of other organisms. The latter included several bacteria and a mold. Pure cultures were secured of all the organisms found.

Through the kindness of R. A. Young of the Department of Agriculture a second lot of corms and tubers was received in March. A number of these were apparently infected with the same disease and organisms were again isolated. It was found that the yeasts greatly predominated and that the bacterial colonies were different from those previously noted. Mold colonies rarely appeared and were of distinctly different organisms. Attention was therefore centered upon the yeasts as possible causal factors in the decay. They were cultured in 10 per cent cane sugar solution, in dasheen agar tubes, and on dasheen cylinders, all sterilized before inoculation. Uncooked pieces of dasheen tissue, cut under sterile conditions and dropped into flasks of sterilized water, also served as a culture medium. The growth of the yeasts and the fermentation accompanying it was found to be much more vigorous in the vessels containing the uncooked tissue. In the other media, endospores were soon formed, the vegetative development being slight.

The attempts to inoculate healthy corms and tubers with the yeasts were handicapped by the difficulty of recognizing diseased specimens by surface indications. The photographs show specimens that appeared sound on the exterior but were badly decayed internally. Such specimens indicated that the entrance of the organisms had been at the points of removal of the lateral branches. Wound inoculations were resorted to and proved successful. The surface of an apparently sound specimen was sterilized with formalin, one end removed with a sterilized knife, the tissue pierced several times with a sterilized needle, and the specimen suspended for a few minutes with the pierced end dipping into a pure liquid culture of active yeasts. After being so inoculated, the specimen was left suspended over a sterilized tumbler in a clean place. About half

the inoculations made in this way resulted, after a few days, in the fermentation of the sound tissues adjacent to the lines made by the wounding needle. If allowed to develop, the diseased portion increased, but no specimens became completely decayed. The amount of decay indicated in the photograph represents the maximum for any specimen examined, whether naturally or artificially infected. The limited amount of material

FIG. 1. CORMS INFECTED BY YEASTS

The specimens were pared before being photographed. The white marks indicate the limits of the infected tissues, which limits appear pink or brown in the specimens. Note the points where lateral shoots have been removed; infection probably occurred at these points.

for experimentation did not allow careful determination of the optimum conditions for the development of the disease.

A third lot of material received from the Department of Agriculture was found to be so badly infected with the powdery gray rot *Fusarium solani* (1) that no inoculations were attempted.

These observations indicate that under some conditions wild yeasts secure access to the tissues of the corms and tubers of the dasheen, probably in the removal of the lateral shoots, and cause a fermentation of the sugars,

rendering the affected parts useless for food. True parasitism of the yeast is not established by the observations, but rather their capacity to initiate and carry on a fermentation in the injured tissues, which in turn spreads to surrounding healthy tissues.

UNIVERSITY OF CINCINNATI

LITERATURE CITED

(1) HARTER, L. L. Storage-rots of economic aroids. Journal of Agricultural Research **6**: 549–572. 1916.

REVIEWS

Enfermedades y Plagas del Cacao en el Ecuador y metodos modernos apropiados al cultivo del cacao. By J. B. Rorer, Mycologist of the Board of Agriculture of Ecuador. Report presented to the president and members of the Association of Agriculturists of Ecuador, 80 pp. 22 illustrations.

In this report, which is the result of two months' investigations on eighteen of the cacao plantations of Ecuador, Mr. Rorer describes the diseases and pests of cacao in that country. He reports two fungi, probably new species, as of considerable importance in addition to the more widespread Phytophthora fungus.

The subject is treated under the following divisions: (1) Diseases of the fruit or pods, which include the wet rot due to a species of Monilia, the black spot due to *Sphaeronema sp.*, the black rot caused by *Phytophthora Faberi*, and those due to snow or frost. (2) Diseases of the trunk and of the branches, including what is called the "machete" or cutlass disease, which is caused by the same Sphaeronema that infests the pods, and is induced by cuts or wounds made by "machetes," the "pajarito" mentioned as a flowering parasite and presumably a mistletoe, and mosses and lichens. (3) Insect pests of the pods, branches, and leaves, including animals, birds, leaf-cutting ants, the cacao beetle, *Steirostoma sp*, and the serious pest the "moquilla" or *Monalonion atratum* and *M. dissimulatum*.

In addition are notes upon modern methods of cultivating cacao concerning which Mr. Rorer is an authority from long experience in Trinidad and other countries.

The paper is a distinct contribution to our literature on cacao diseases, serves to emphasize the necessity for more pioneer work in plant pathology and economic entomology in tropical American countries, and serves to make us wish that the author of the paper could arrange to publish a résumé of the known information concerning cacao diseases in these countries.

JOHN R. JOHNSTON

PHYTOPATHOLOGICAL NOTES

In quoting from a personal letter, in an article recently published in PHYTOPATHOLOGY entitled "Notes on the overwintering of forest tree rusts," an error appeared, and in justice to the author of the letter a correction is hereby made. On page 56, second line from top, of PHYTOPATHOLOGY, Volume 8, the portion of the sentence reading "in catkins and buds of certain other species," should read, "in catkin buds of certain other species."

J. R. WEIR AND E. E. HUBERT

Early occurrence of citrus scab in Japan. In the herbarium of the Hong Kong Botanic Gardens is a collection of *Citrus nobilis* Lour, made in 1863 at Nagasaki, Japan, by Maximowicz. This specimen shows a number of citrus scab lesions and thus constitutes a very early record of the occurrence of citrus scab in Japan. The early occurrence of this disease in Japan and the general distribution of citrus scab throughout the citrus growing regions of South China indicate that this disease may be indigenous in the Orient.

H. ATHERTON LEE

Personals. Prof. Arthur Harmount Graves, formerly of Yale, has been apppointed by the Office of Investigations in Forest Pathology, Bureau of Plant Industry, for work during the summer months on problems relating to disease resistance in the chestnut tree.

Prof. J. M. LeCato, formerly head of the Biology Department of Marshall College, Huntington, W. Va., has been appointed a pathologist in the Bureau of Plant Industry to take up extension work on the control of diseases of truck crops in Virginia, with headquarters at Blacksburg.

Dr. D. H. Rose, formerly pathologist at the Missouri State Fruit Experiment Station, Mountain Grove, Mo., has accepted an appointment in the Office of Fruit Disease Investigations, Bureau of Plant Industry, to take up work on the pathological aspects of market inspection of fruits.

LITERATURE ON PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY, AND FLORENCE P. SMITH, ASSISTANT

July, 1918

Allard, Harry Ardell. Effects on various salts, acids, germicides, etc., upon the infectivity of the virus causing the mosaic disease of tobacco. Jour. Agr. Research, **13:** 619–637. Je. 17, 1918.

American Plant Pathologists. War Emergency Board. Minutes of war emergency conference of Great Plains plant pathologists, Lincoln, March 19–20, 1918. Phytopathology **8:** 301–303. My. 1918.

Arthur, Joseph Charles. Uredinales of Guatemala based on collections by E. W. D. Holway. Amer. Jour. Bot. **5:** 325–336. Je. 1918.

I. Introduction, Coleosporiaceae and Uredinaceae.

——— and **Johnston, John Robert.** Uredinales of Cuba. Mem. Torrey Bot. Club **17:** 97–175, illus. Je. 1918.

New species—*Cronartium notatum, C. wilsonianum, Cionothrix cupaniae, Ravenelia subensis, Uromycladium* (?) *cubense, Uromyces cupaniae, Puccinia anthephorae, P. striolata, P. barbatula, P. invaginata, P. johnstonii, P. megalospora, P. adenocalymnatis, P. fuscella, Aecidium pisoniae, A. simplicius, Uredo saviae, U. sapotae, U. lucumae.*

Averna-Saccá. Rosario. Exame microscopico das jaboticabas enviadas pela directoria de agricultura. Ferrugem das jaboticabeiras. Bol. Agr. São Paulo **19:** 68–69. Ja. 1918.

——— Molestia das videiras. Bol. Agr. São Paulo **19:** 214–220, illus. Mr. 1918.

Glocosporium ampelophagum, G. physalosporae.

——— Molestias encontradas sobre as folhas de fumo e de gergelim provenientes de Soccorro (Pernambuco) remettidas pela directoria de agricultura. Bol. Agr. São Paulo **18:** 984–986. D. 1917.

Cercospora solanicola Atk. on tobacco, *Cercospora* sp. on *Sesamum indicum.*

Reprinted in Bol. Agr. São Paulo **19:** 70–71. Ja. 1918.

Bocher, H. Le mildiou ou maladie des pommes de terre. La Vie Agr. et Rur. **7:** 369–370. My. 26, 1917.

Bruner, Stephen C. La pudricion del tomate y modo de evitarla. Rev. Agr., Com. y Trab. Cuba **1:** 300–303, illus. Je. 1918.

Burkholder, Walter H. The production of an anthracnose-resistant white marrow bean. Phytopathology **8:** 353–359. Jy. 1918.

[1] This list includes references, both American and foreign, to the literature of plant pathology and mycology of interest to pathologists. Foreign references published since January 1, 1917, have been included beginning with the list appearing in vol. 7, no. 3, June, 1917.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agri., Washington, D. C.

Carpenter, Clarence Willard. A new disease of the Irish potato. Phytopathology **8:** 286–287, pl. Je. 1918.
In Hawaii. Caused by a mite.

Dodge, Bernard Ogilvie, and **Adams, James Fowler.** Some observations on the development of Peridermium cerebrum. Mem. Torrey Bot. Club **17:** 253–261, illus., pl. 2–6. 1918.

Duff, George H. Some factors affecting viability of the urediniospores of Cronartium ribicola. Phytopathology **8:** 289–292, illus. Je. 1918.

Elliott, John Asbury. Storage rots of sweet potatoes. Arkansas Agr. Expt. Sta. Bul. 144, 12 p., 4 pl. My. 1918.

Faull, Joseph Horace. Fomes officinalis (Vill.) a timber destroying fungus. Trans. Roy. Canad. Inst. **11:** 185–209, pl. 18–25. N. 1917.
Literature cited, p. 207–209.

Fisher, Durward Frederick. The abuse of water on fruit and trees. Proc. Washington State Hort. Assoc. **14:** 19–25. 1918.

Gillespie, Louis J. The growth of the potato scab organism at various hydrogen ion concentrations as related to the comparative freedom of acid soils from the potato scab. Phytopathology **8:** 257–269. Je. 1918.
Literature cited, p. 268–269.
Actinomyces chromogenus.

Glover, H. M. A fungus attack on the deodar. Indian Forester **43:** 498–499, pl. 26. N./D. 1917.
Undetermined.

Graff, Paul Weidemeyer. Philippine micromycetous fungi. Mem. Torrey Bot. Club. **17:** 56–73. Je. 1918.
Ascophanous verracosporus, Meliola litseae, Phyllosticta brideliae, new species.

Hemmi, Takewo. On the Glocosporiose of Caladium. Trans. Sapporo Nat. Hist. Soc. **7:** 41–70, pl. Ap. 1918.
Literature cited, p. 69–70.
In Japanese.

Jones, Donald F. Segregation of susceptibility to parasitism in maize. Amer. Jour. Bot. **5:** 295–300. Je. 1918.
Literature cited, p. 299–300.

Jones, Lewis Ralph, and **Gilbert, William Williams.** Lightning injury to herbaceous plants. Phytopathology **8:** 270–282. Je. 1918.

Kauffman, Calvin Henry. Unreported Michigan fungi for 1915 and 1916, with an index to the hosts and substrata of Basiodiomycetes. Ann. Rpt. Michigan Acad. Sci. **19:** 145–157. 1917.

Keitt, George Wannamaker. Inoculation experiments with species of Coccomyces from stone fruits. Jour. Agr. Research **13:** 539–569, 3 fig., pl. 55–59. Je. 10, 1918.

Krakover, L. J. The leaf-spot disease of red clover caused by Macrosporium sarcinaeforme Cav. Ann. Rpt. Michigan Acad. Sci. **19:** 273–328, pl. 12–16. 1917.
Literature cited, p. 322.
Thesis.

Kulkarni, G. S. Smuts of jowar (sorghum) in the Bombay Presidency. Bul. 78 Agr. Research Inst. Pusa, 26 p., 6 pl. 1918.

Levine, Moses N. A third biologic form of Puccinia graminis on wheat. Jour. Agr. Research **13:** 651–654. Je. 17, 1918.

Lind, Jens, and **Ravn, Frederik Kølpin.** Forsøg med midler mod byggets stribesyge. Tidsskr. Planteavl **25:** 56–116. 1918.
Litteratur, p. 115–116.
125. Beretn. fra Stat. Forsøgsvirks. i. Plantekult.

Ludwig, Clinton Albert. The effect of tobacco smoke and of methyl iodide vapor on the growth of certain microorganisms. Amer. Jour. Bot. **5:** 171–177. Ap. 1918.
Literature cited, p. 177.

McClintock, James Albertine, and **Smith, Loren B.** True nature of spinach-blight and the relation of insects to its transmission. Jour. Agr. Research **14:** 1–60, pl. Jy. 1, 1918.

McCubbin, William A. Public school survey for currant rust. Phytopathology **8:** 294–297. Je. 1918.

Mackie, D. B. Some observations on citrus canker. California Citrograph **3:** 231, 244–245. Ag. 1918.
List of susceptible varieties, especially in the Orient, cost of eradication in Florida, etc.

MacMillan, H. G. Sunscald of beans. Jour. Agr. Research **13:** 647–650, pl. 64–66. Je. 17, 1918.

Martin, William H. Dissemination of Septoria lycopersici Speg. by insects and pickers. Phytopathology **8:** 365–372. Jy. 1918.
Literature cited, p. 372.

Matz, Julius. Report of the laboratory assistant in plant pathology. Florida Agr. Expt. Sta. Rpt. [1916] **17:** 87R–94R, illus. 1918.
Pecan dieback. *Botryosphaeria berengeriana;* an undescribed Gnomonia on pecan leaves.

Orton, William Allen. Breeding for disease resistance in plants. Amer. Jour. Bot. **5:** 279–283. Je. 1918.
Literature cited, p. 284.

Pammel, Louis Hermann. Recent literature on fungous diseases of plants. Rpt. Iowa State Hort. Soc. **52:** 193–251. 1918.

Pierce, Roy Gifford. Notes on Peridermiums from Ohio. Need of pathological viewpoint in nursery inspection. Phytopathology **8:** 292–294. Je. 1918.

Reddick, Donald. Lightning injury to grape vines. Phytopathology **8:** 298. Je. 1918.

Rees, Charles C. The rusts occurring on the genus Fritillaria. Amer. Jour. Bot. **4:** 368–373, illus. Je. 1917.

Rhoads, Arthur S., Hedgcock, George Grant, Bethel, Ellsworth, and **Hartley, Carl.** Host relationships of the North American rusts, other than Gymnosporangiums, which attack conifers. Phytopathology **8:** 309–352. Jy. 1918.
Literature cited, p. 346–352.

Rosenbaum, Joseph, and **Ramsey, Glen B.** Influence of temperature and precipitation on the blackleg of potato. Jour. Agr. Research **13:** 507–513. Je. 3, 1918.

Sawada, Kaneyoshi. A new rust fungus parasitic on the cultivated rose. Trans. Sapporo Nat. Hist. Soc. **7:** 36–40, illus. Ap. 1918.
Kuehneola rosae n. sp.
In Japanese, description of species in English.

Schoevers, T. A. C. Meer staatsbemoeiing op het speciale gebied van bestrijding van plantenziekten en schadelijke dieren. Cultura **30:** 164–171. My. 1918.

Seaver, Fred Jay, and **Horne, William Titus.** Life-history studies in Sclerotinia. Mem. Torrey Bot. Club **17:** 202–206, pl. 3. Je. 1918.

S. geranii sp. nov.

Sherbakoff, Constantin Demetry. Report of the associate plant pathologist. Florida Agr. Expt. Sta. Rpt. [**1916**]/**17:** 76R–86R, illus. 1918.

Damping off; phomopsis of egg plant; buckeye rot of tomato, *Phytophthora terrestria;* bacterial spot of pepper; pepper pink joint; other diseases of importance.

Smith, Erwin Frink, and **Godfrey, George Harold.** Brown rot of Solanaceae on Ricinus. Science n.s. **48:** 42–43. Jy. 12, 1918.

South, F. W. Buried coconut trunks and root diseases of rubber. Agr. Bul. Fed. Malay States **6:** 269. Mr. 1918.

Stakman, Elvin Charles, Parker, John Huntington, and **Piemeisel, Frank Joseph.** Can biologic forms of stemrust on wheat change rapidly enough to interfere with breeding for rust resistance. Jour. Agr. Research **14:** 111–123, pl. Jy. 8, 1918.

Stevens, H. E. Lightning injury to citrus trees in Florida. Phytopathology **8:** 283–285, illus. Je. 1918.

——— Report of plant pathologist. Florida Agr. Expt. Sta. Rpt. [**1916**]/**17:** 66R–75R, illus. 1918.

Citrus diseases—gummosis, melanose, canker, foot rot; some diseases of the season.

Stewart, Vern Bonham. Exclusion legislation and fruit tree production. Phytopathology **8:** 360–364. Jy. 1918.

U. S. Department of Agriculture. Federal Horticultural Board. Quarterly letter of information no. 27, 17 p. Ap. 1918.

——— ——— Service and regulatory announcements. March: 25–38, My. 9; April: 39–52, Je. 18; May: 53–63, Je. 28. 1918.

U. S. Department of Agriculture. Bureau of Plant Industry. Plant Disease Survey. Plant disease bulletin **2:** 19-41, My. 15; 42–53, Je. 1; 54–65, Je. 15; 66–80, Jy. 1. 1918.

Van der Bijl, Paul Andries. A study on a "mottled" disease of the black wattle. Union S. Africa Dept. Agr. Div. Bot. Sci. Bul. 4, 20 p., 9 fig. 1914.

Van Fleet, Walter. Hybrids and other chestnuts for blight districts. Rpt. Proc. Ann. Meeting North. Nut. Grow. Assoc. **7:** 54–57. 1917.

Voglino, Pietro. Intorno al marciume radicale del gelso. Bul. Agr. Milan **51,** no. 29: [1–2]. Ag. 10, 1917.

Weir, James Robert. Forest disease surveys. U. S. Dept. Agr. Bul. 658, 23 p., illus. 1918.

Wilson, Guy West. Studies in North American Peronosporales VII. New and noteworthy species. Mycologia **10:** 168–169. My. 1918.

Peronospora grisea, P. seymourii, Rhysotheca acalyphae n. sp.

Wormald, H. "Brown rot" of apples. Jour. Bd. Agr. [London] **25:** 299–302, pl. Je. 1918.

Young, Harry C. A method for determining the fungicidal coefficient of lime sulphur and other common fungicides. Ann. Rpt. Michigan Acad. Sci. **19:** 221–236. 1917.

Bibliography, p. 235–236.

Zeman, V. Consideraciones sobre el carbón y la carie de los cereales. Rev. Facult. Agron. y Vet. La Plata **12:** 330–340. 1917.

[PHYTOPATHOLOGY for September, 1918 (**8:** 457–506), was issued September 12, 1918.